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ORIGINAL ARTICLES.

I.—On the Eastern Margin of the North Atlantic Basin.

By Wilfrid H. Hudleston, M.A., F.R.S., F.L.S., F.G.S., etc.

(*Concluded from the March Number, p.* 105.)

Part II.—The Icelandic Shallows.[1]

(PLATES V, VI, and VII.)

QUITTING the more northern parts of the great Atlantic depression, we have next to consider an extensive water-space of a much shallower character. Here the volcanic masses of Iceland and the Færoes with their submarine attachments have produced a marked effect on the depths of the ocean. The Norwegian Atlantic connects with the main Atlantic by three straits, whose central channels present the following depths at their shallowest :—

The Færoe-Shetland Channel	...	...	...	319 fathoms.
The Færoe-Iceland Platform	...	...	...	277 ,,
The Denmark Straits	...	...	...	319 ,,

The Færoe-Shetland Channel, sometimes known as the Lightning Channel, is one of great interest to us. It runs up from the axis of the Norwegian Atlantic in depths of about 600 fathoms, when it suddenly abuts on the Wyville Thomson ridge, which is a kind of submerged causeway running from the Shetland bank to the Færoe bank. The extreme depth, in the centre, to which this ridge is now submerged, may be taken at 319 fathoms, or 1,914 feet. To make things perfectly safe, we should require an elevation of this part of the sea bed to the extent of 2,000 feet in order to walk over to Iceland without wetting our shoes, and an equal amount of elevation in the Denmark Straits would enable us to extend our journey to Greenland. But it must not be supposed that an elevation of 2,000 feet would do more than produce a very narrow neck of land; and even an elevation of 3,000 feet, if Mohn's chart is to be relied on,[2] would still confine us to the use of the narrow Wyville Thomson isthmus. It should be noted that the Lightning Channel runs up in almost direct continuation of the axial depths of the

[1] Figures 2, 3, and 4 (forming Plates V, VI, and VII), being reductions of portions of the Admiralty charts, are specially intended to illustrate Parts II and III.

[2] According to Bartholomew's map illustrating Nansen's paper in the Geographical Journal, the Lightning Channel is bridged by *two* submerged necks of land.

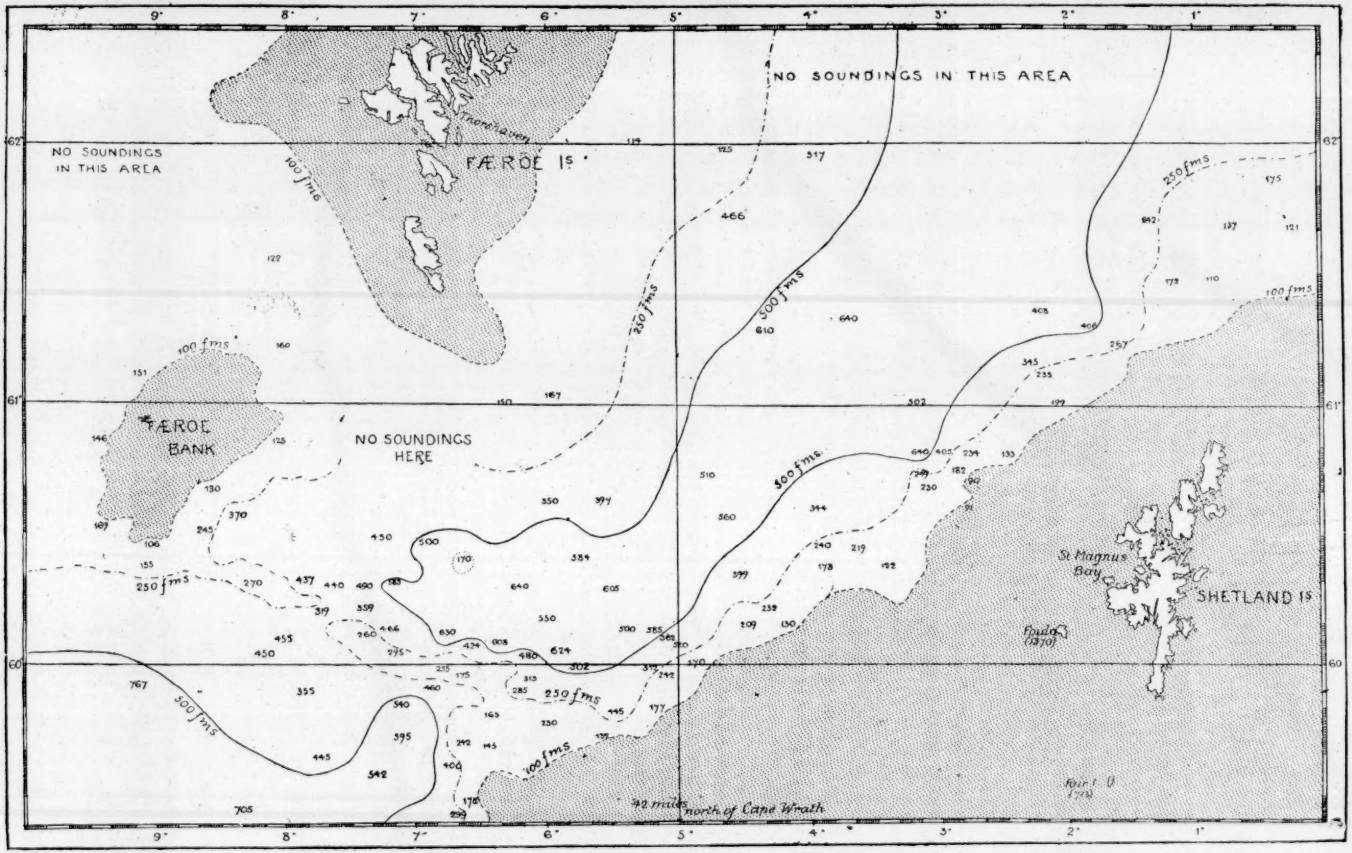

FIG. 2.—The Lightning Channel.

Reduced from No. 2 Admiralty Chart; with contours based upon the soundings. The water-space within the 100-fathom line is stippled.

Norwegian Atlantic, to meet on the other side of the ridge the great embayment of the British Atlantic, which lies betwixt Ireland and the Rockall platform.

Throughout this part of the ocean the suboceanic continental slope is not always to be made out with certainty. It is very perceptible off Romsdal in Norway, but less distinct between that coast and Shetland, off the mouth of the North Sea. Here the contours are more gradual even than off the mouth of the Barents Sea. Nevertheless, it is within this marginal slope that all the terrigenous deposits lie, whilst outside, i.e. to the westward beyond the centre of the Lightning Channel, all the known land, and presumably most of the submerged land, is of igneous origin.[1] According to my view, the continuation of the suboceanic continental slope is to be found along the south-east side of the Lightning Channel, which is tolerably steep in places. Thus, about 55 miles W.N.W. of St. Magnus Bay, in the mainland of Shetland, the edge of the Continental platform lies in about 90 fathoms of water; from this edge the submarine slope descends to 640 fathoms in the space of 15 miles, showing an inclination of 1 in 24, or 2½°. This is the steepest declivity I can find in connection with the Lightning Channel.

South of the Wyville Thomson ridge the suboceanic continental slope may be traced in the Vidal bank, which runs parallel with the Hebrides; here the contours are rather wide apart and the inclination is gradual. The Vidal bank forms the eastern margin of that great embayment of the Atlantic which runs up between Scotland and Rockall. The Rockall bank is evidently of igneous and not of terrigenous origin, and may be classed among the group of oceanic islands; it is probably in alignment with the Færoe bank, 280 miles towards the north-west, though never actually connected with it. The rock itself is only 70 feet above the surface of the water, and consists of an acid igneous product, named by Professor Judd 'rockallite,' but most of the specimens dredged from the bank are said to be of basaltic character. (Trans. Roy. Irish Acad., xxxi, 1897, p. 39.)[2]

Following the submerged continental slope in continuation of the Vidal bank, a considerable change is noted off the coast of Connaught, where the contours close in rapidly, and a deep embayment of the Atlantic approaches within 80 miles of Broadhaven. South of this embayment there is a large submerged

[1] Dr Thoroddsen ("Exploration in Iceland") speaks of fragments of a tableland, originally connected, forming a 3,000 feet thick layer of breccia, which covered the whole inner surface of Iceland, and which has been for the most part removed by erosion; the strata underlying the breccia is everywhere Tertiary basalt. Unfortunately, the author does not say of what the breccia consists. (Geographical Journal, November, 1898, p. 497.)

Postscript.—In a letter dated Copenhagen, December 12, 1898, Dr. Thoroddsen states that he refers to the ancient volcanic palagonite breccia with smaller and larger fragments of basalt, dolerite, etc. It is obvious, therefore, that, so far as we know, all the materials which go to form this large island are of igneous origin, not excepting the Tertiary leaf-beds, which appear to owe their mechanical sediments exclusively to this source.

[2] For a notice of Rockall, see infra, p. 163.

FIG. 2.—The Lightning Channel.

Reduced from No. 2 Admiralty Chart; with contours based upon the soundings. The water-space within the 100-fathom line is stippled.

platform, at a lower level for the most part than the usual continental shelf. This has a very irregular surface, with depths ranging from 130 to 240 fathoms, and it has its termination seawards in the direction of the Porcupine bank. This irregular platform causes a westward bulge of the Continental submergence, which here presents an edge which is also very irregular and unequal in its depths. In places the suboceanic slope is pretty steep, especially where it faces the north. Thus we find a drop from 135 to 1,350 fathoms in a distance of 23 miles, giving an inclination of 1 in 17, or $3\frac{1}{2}°$. I cannot find anything steeper than this in connection with the Porcupine bank, although it has been stated that the slopes are precipitous.

Before going south of the Porcupine bank, it may be convenient to consider for a moment the possible geological history of the Atlantic shallows, as we may term that part of the ocean which lies betwixt the British Isles and the south-east coast of Greenland. That some sort of a bridge across the Atlantic may have existed during portions of Tertiary time in these quarters seems not an incredible supposition. Both botanists and zoologists require it. We have already seen that an elevation of 2,000 feet would suffice to effect a land communication between the British Isles and East Greenland at the present day. In a volcanic region like this we may readily concede such a communication by means of sporadic islands, involving local uplifts to the amount of 2,000 or even 3,000 feet, without postulating such a general uplift as would make, for instance, the coastline of the North of Scotland coincide with the 500-fathom line. No doubt such a state of things is regarded as probable by eminent British geologists, who differ chiefly as to the period when this occurred. It is impossible on the present occasion to do more than allude to such views, and I am by no means prepared to deny that something of the kind may have taken place in Middle Tertiary time, though I fail to perceive the absolute necessity for it. With respect to the general effect of the partial bridging of the Atlantic upon the theory of the permanence of ocean basins, bearing in mind the volcanic nature of the region in question, we may regard the Atlantic shallows as an oscillating area which lies athwart the general trend of the great meridional depression. Under certain circumstances this oscillating area may break the continuity of the great Atlantic depression, and even bridge it for a time.

It would be interesting at this stage of the inquiry to ascertain how far the views of Professor Spencer, as stated in a recent communication to the Geological Magazine, are really applicable to this side of the Atlantic; and whether a study of the Admiralty charts affords any confirmation of his statements or his theories. It is not necessary to refer to the other side of the Atlantic beyond remarking that Professor Spencer, having long studied the region of the Caribbean Sea — perhaps the most unstable on the surface of the earth — appears to have conceived exaggerated notions as to 'epeirogenic' uplifts on both sides of the Atlantic. An elevation

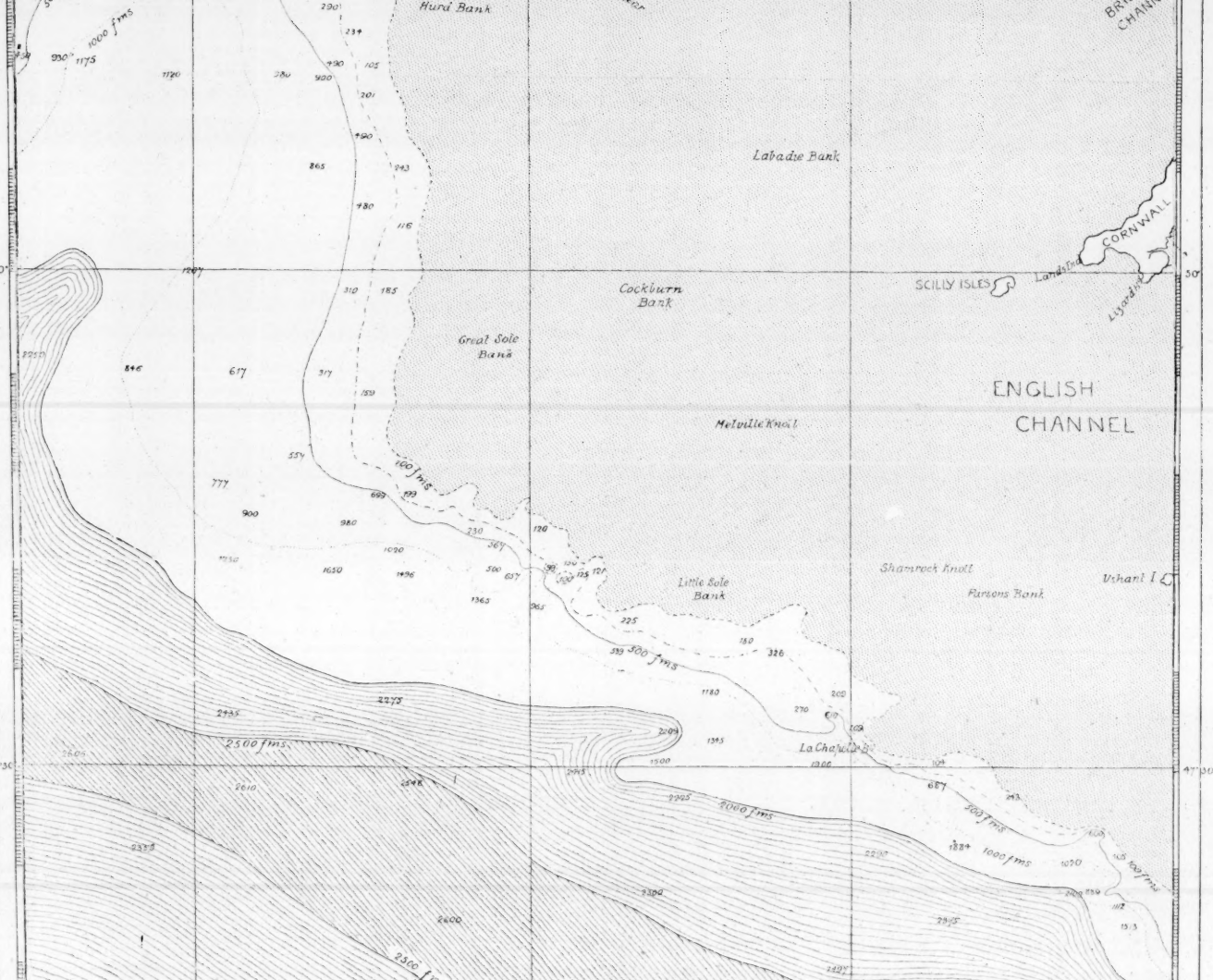
Hurd Bank
Labadie Bank
CORNWALL
SCILLY ISLES
Cockburn Bank
Great Sole Bank
ENGLISH CHANNEL
Melville Knoll
Little Sole Bank
Shamrock Knoll
Parsons Bank
Ushant I
La Chapelle Bk
100 fms
300 fms
500 fms
1000 fms
2000 fms
2500 fms
50°
47°30'

FIG. 3.—The British-Biscayan Atlantic

Reduced from No. 1 Admiralty Chart; with contours based upon the soundings. The water-space within the 100-fathom line is stippled.

of 12,000 feet he claims for the continent of No
considers that the period of greatest elevation w
In speaking of what he calls the submerged p
Atlantic, he points out that it rises northwards t
and according to his view the several channels
allusion has already been made, represent so
presumably, were indented by meteoric erosio
of principal emergence. He particularly men
channel between Færoe and Shetland, correspo
depression of the Wyville Thomson ridge, a
a great valley which off the north-west of Irela
a depth of 9,980 feet.

This of course must be the Rockall gulf or
not quite easy to follow the statements and rea
Spencer with reference to the inequalities in th
But if the bed of the North Atlantic has at
Middle Tertiary period undergone a general u
it is obvious that the Rockall gulf must have
it seems as though Professor Spencer would h
this gulf has been carved out like an ordinary va
of emergence. Apart from considerations as to
of time which would be required to excavate
deep with sides sloping at a very moderate ang
probable that the Rockall gulf, the Lightnin
deeps of the Norwegian Atlantic are all due, in
causes acting along the general alignment of the

PART III.—THE BRITISH ATLANTIC AND I

Some of the hydrographical details supplied
charts are now continued so as to include the S
Bay of Biscay, and the north coast of Spain.
intended to extend the investigation as far as the
but the paper is becoming longer than I expecte
be dealt with briefly.

A long finger of the Atlantic deeps penet
platform which is connected with the Porcupi
the sake of distinction, I would call the 'Gulf
Bantry Bay the 100-fathom line and the 1,0
45 miles apart, giving an incline of 1 in 80,
than one degree. Beyond Bantry Bay the 10
nearly due south for 180 miles; the contours are
apart, but gradually become closer. A great ch
the neighbourhood of the Sole banks, which lie fr
south of Cape Clear. Here the submerged
attains its greatest width, and the edge now
eastward; whilst the contours of the submerge
approach each other in a very irregular manner.

Between the Sole banks and La Chapelle bank
irregular indentations of the 100-fathom line,
the discharge of the rivers of St. George's C

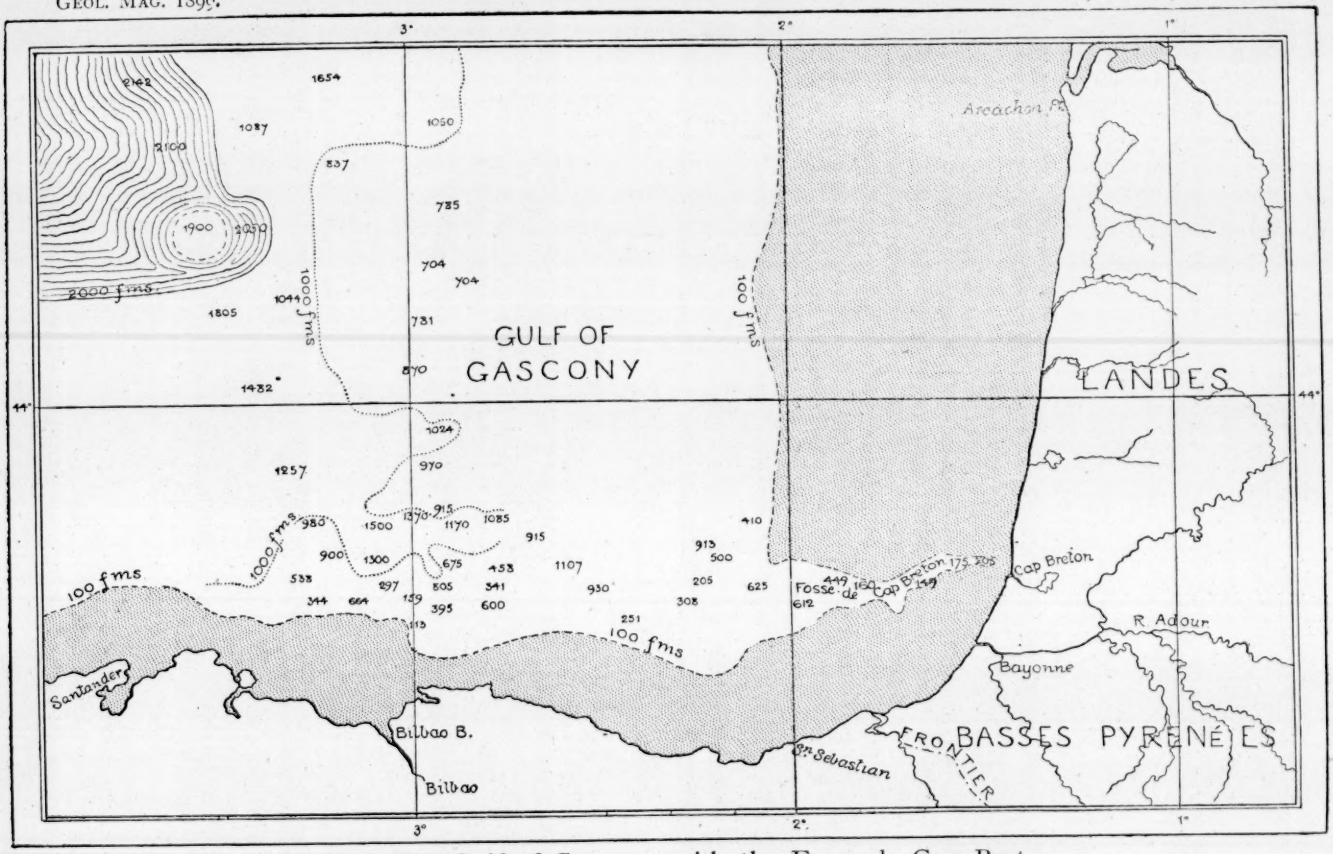

FIG. 4.—The Gulf of Gascony, with the Fosse de Cap Breton.

Reduced from No. 1,104 Admiralty Chart. The water-space within the 100-fathom line is stippled.

English Channel respectively. Immediately south of this occurs the great plunge into the depths of the Bay of Biscay. The soundings along the face of the suboceanic slope hereabouts are very irregular and puzzling; so much so that it is not easy to deduce any mean angle of inclination. This irregularity in the soundings seems more or less to prevail until the 2,000-fathom contour is reached, beyond which the ocean floor becomes much flatter, the depths ranging from 2,200 fathoms to 2,768 fathoms in the centre of the Bay. At La Chapelle bank, which is about 125 miles W.S.W. of Ushant, there is a fall from the 100-fathom contour to 1,900 fathoms in about 20 miles. This is rather steeper than 1 in 10, or about 6°. No rock is marked in these soundings, but deposits of a varying character.

Following the course of the suboceanic slope for about 100 miles south-east of La Chapelle bank, there is a third remarkable deflection of the contours, similar to those indicated off the Little Sole bank and La Chapelle bank. To judge from the soundings there are some curious features here. The distance between the 100-fathom line and the 2,000-fathom line is only 23 miles, giving a mean slope of about 1 in 11 or nearly 5°. But there are greater irregularities than these. For at one spot 600 fathoms is marked just outside the 100-fathom line; whilst in another, further out to sea, a distance of about seven miles, separate soundings of 880 fathoms and 2,100 fathoms respectively, thus giving a slope of 1 in 5 or 11°. In this latter case the irregularity is not connected with the edge of the 100-fathom platform, but may be said to belong to abyssal depths.

Further towards the south-east, off the town of La Rochelle, the following conditions obtain. The continental platform, down to the 100-fathom line, is about 130 miles wide, but the terminal edge is pretty sharp, since we obtain a depth of 2,000 fathoms in the next 22 miles. This gives about the same angle of inclination for the suboceanic continental slope as at La Chapelle, and may perhaps be taken as representing the steeper averages on the French side of the Bay of Biscay, viz. 6° or thereabouts.

The head of the Gulf of Gascony presents some remarkable features which have long attracted attention, though their full import is by no means certain. Here the coasts of France and Spain almost form a right angle to each other, whilst the direction of the suboceanic slope, flanking the Bay of Biscay, is shifted from south-east to nearly due west. The contours at the head of the Bay are somewhat confusing, and this is made worse by a number of incomplete soundings. The respective peculiarities of the French and Spanish territories are to a certain extent prolonged under water, so that the low-lying coasts of the Gironde and the Landes are fully 100 miles distant from the 1,000-fathom contour, whilst the more mountainous Spanish coast near Bilbao is less than 20 miles from it. Almost exactly in the angle, at the very head of the Gulf of Gascony, the 100-fathom platform, here about 30 miles in width, is pierced by the Fosse de Cap Breton, which has already

a depth of 205 fathoms close to the coast, and which may be traced for 30 miles out to sea until it attains a depth of over 600 fathoms.

This curious place has generally been regarded as the submerged channel of the predecessor of the river Adour, which now enters the sea a few miles to the southwards. To this point I will draw attention presently. Meanwhile there are a few hydrographical details in connection with this submerged channel which might be mentioned. Like so many sunken channels and fjords, not excepting the so-called Channel of Norway, it is very deep at the head, deeper in fact than in any other portion of the first 15 miles. There are also indications of a lateral channel (a short cirque having a depth of 336 fathoms). The mouth is about 10 miles across, and has a maximum depth of 530 fathoms below the submerged continental shelf. This gives a slope from the edge of the shelf to the centre of the channel of 1 in 8, or 7°.

Thirty-five miles to the westward another channel is marked on the chart, in presumed continuation of this one; it is situated about 30 miles to the north of the town of Bilbao. In this channel depths ranging from 1,000 to 1,500 fathoms occur, apparently sunk in a submerged platform, which itself has an extremely irregular surface. A map of the soundings at this place is given by Professor Milne, who quotes it as a locality notorious for cable fracture.[1] He states that the fractures usually happen in the month of March, when sometimes portions of the cable, four or five miles in length, are buried. The fractures are attributed to the action of a submarine current, caused by the piling up of surface water, cutting the prolongation of a river bed with steep walls; these walls when undercut are believed to fall in such masses as to bury the cable. No rock is marked in these soundings, which yield clay, stiff clay, mud, and sand. In this locality the 100-fathom line lies 12 miles off the coast; and from this edge to the 1,500-fathom sounding in the supposed channel is a distance of 11 miles. This gives a mean slope of 1 in 7, or 8°, but pitches much steeper than this in all probability occur. There are several indications that this depth of 1,500 fathoms represents a hole rather than a channel, for the next sounding seawards shows only 1,250 fathoms.

Certain bathymetrical features in connection with the Bay of Biscay may be mentioned here. The deepest sounding shown on the chart (No. 1,104), viz. 2,788 fathoms, is about 100 miles north-west of the supposed channel or cañon of Bilbao. From this depth the floor of the bay, according to the soundings, rises very slightly towards the ocean. If this floor was uplifted equally to the extent of 2,700 fathoms, or 16,200 feet, there would remain a depression of limited extent, 88 fathoms deep, about 100 miles N.N.W. of Santander; all the rest of the floor of the bay would be dry land. Generally speaking, deep water follows pretty closely on the Cantabrian chain. In the vicinity of Cape Ortegal, where the coast of Spain begins to trend south-west, before assuming a southerly direction off Cape Finisterre, there are cases where the suboceanic

[1] Geographical Journal, September, 1897, p. 273.

continental slope is very steep. I will give two instances. (1) Off Rivadeo the 100-fathom platform is of unusual width for this coast—nearly 30 miles, in fact; from the edge of this platform a depth of 1,130 fathoms is obtained in the next 5 miles, giving an incline of 1 in 4, or about 13°. It is probable that this is a hole, and there are indications of still steeper gradients in the vicinity, since at some little distance outside the edge of the shelf a small bank is marked with only 63 fathoms of water, within $3\frac{1}{2}$ miles of the depth in question; this shows a gradient of nearly 1 in 2, or 25°. (2) Exactly off Cape Ortegal itself the 100-fathom platform has a width of 15 miles; from the edge of this platform a depth of 2,515 fathoms is obtained in the next 13 miles. This gives a gradient of 1 in 5, or 11°, for the suboceanic continental slope off Cape Ortegal. In this case, if we reckon the total distance from the coastline rather than from the edge of the continental shelf, we obtain a fall of 2,515 fathoms in 28 miles, showing a gradient of 1 in 10, or rather less than 6°.

It is now time for me to glance briefly at some of the geological inferences which have been drawn from the bathymetrical conditions made known in connection with the Bay of Biscay and its surroundings. It will be hardly necessary to say that Professor Spencer sees cañons, cirques, and escarpments in all these things; whilst in Professor Hull the American epeirogenists have found an able ally on this side of the Atlantic, as shown in his recent "Investigations regarding the Submerged Terraces and River Valleys bordering the British Isles."[1] Professor Hull wields his pencil so skilfully under the guidance of the scientific imagination that we cannot fail to be interested in his charts and diagrams, even if we do not in all cases agree with his interpretations.

So long as Professor Hull confines himself to tracing the old river-courses cut in the continental shelf he is pretty safe.[2] This

[1] Trans. Victoria Institute, 1898.

[2] At the meeting held in the Map Room of the Royal Geographical Society (Jan. 27) for the purpose of hearing and discussing Professor Hull's latest paper on this subject, some of the speakers were disposed to criticize his tracing of the old river-courses cut in the continental shelf—e.g. the River of the English Channel. But this really is a very minor matter, and altogether fails to touch his principal contention. Most persons who have paid attention to the physical geography, past and present, of these Islands agree that the area of the English Channel was at one time sufficiently elevated as to have been within the influence of meteoric erosion: a difference of 100 fathoms would more than effect this. Thus we may readily allow Professor Hull his rivers of the English and St. George's Channels, even if we are disposed to criticize the exact course they may have taken. But the deep sculpturing which he claims to have been effected in the *suboceanic continental slope* (the 'escarpment' of Professor Hull) by these same rivers involves considerations which would land us in serious difficulties. If the 'edge' or angle of the slope was at one time raised 1,000 fathoms above the level of the sea, instead of being 100 fathoms below it as at present, in that case the region now occupied by the English Channel must have been raised to that extent or more, unless the River of the English Channel was endowed with the faculty of running up hill. Suppose we take the period as Pliocene: this means an upland of 6,000 or 7,000 feet above sea-level in the vicinity of the region now occupied by the Straits of Dover, whilst some sixty miles to the northwards the Crags were being deposited in a shallow sea, whose area is now partly occupied by the Suffolk coast. Truly, in this case we should require another 'escarpment' facing the area now

latter represents an old area of emergence of considerable antiquity, and although the edge of the platform is not always in exactly 100 fathoms, yet it is so nearly on that level for great distances as to give an idea of uniformity. It is obvious that the angle, or 'edge,' formed by the submerged platform with the suboceanic continental slope is a feature of considerable importance, and any marked indentations of this edge are worthy of careful notice. The two indentations of the 100-fathom platform in the mouth of the Channel, near the Sole banks, between Cape Clear and Ushant, have been already mentioned as probably representing the mouths of the rivers of the Irish and English Channels, which seem to have entered the Atlantic Ocean not far from each other. But Professor Hull perceives something more than this. For him these two rivers in early Pleistocene time were draining a highland plateau some 6,000 feet above the level of the sea. This, after all, is moderate, being only half of what Professor Spencer requires. The western termination of this elevated plateau was a magnificent 'escarpment,' which, if viewed from the outer ocean, would be found to be 'terrestrial,' not oceanic, in origin. When the two rivers approached the edge of this escarpment they entered the ocean in a series of grand cascades or rapids, which are now represented by the submerged cañons that seam the great suboceanic slopes.

I certainly demur to the view that the suboceanic continental slope represents an 'escarpment' in the geological sense;[1] but it must be admitted that the soundings beyond the edge of the platform, both at the Sole banks and elsewhere in certain localities round the Bay of Biscay, are curious and perplexing, whether the cañon theory be applicable or not. Thus, there are two tongues of deep water which appear to indent the suboceanic slope in connection with the mouth of one of the Channel rivers. This feature is interpreted by Professor Hull as a river-course with two branches enclosing a kind of island between them, and similar cases occur in connection with supposed cañons elsewhere. His drawings are very effective, but the steepness of the supposed gorges is greatly accentuated by the difference between the vertical and horizontal scales. As regards geological age Professor Hull refers the British platform like the American continental shelf to the Mio-Pliocene period. But he refers his 'grand escarpment' to the succeeding early Pleistocene or Glacial stage, when, according to his views, the great continental uplift took place. These conceptions as to the sudden uprise of the sea bed, so as to form an escarpment at that comparatively late date, are certainly opposed to the generalizations of Mr. Jukes-Browne. That author, in "The Building of the British Isles," continuously reduces the land area and increases the sea area from the Oligocene

occupied by the North Sea to meet the difficulty. If we take the period as Pleistocene we are no better off. To enable the River of St. George's Channel to surmount the edge of the 'escarpment' we must raise the drainage area behind, and this it would be difficult to effect without converting the Irish Sea into an inland lake over 6,000 feet above sea-level.

[1] This point is now conceded by Prof. Hull (see GEOL. MAG., March, 1899, p. 132).

period down to the Pleistocene, when the coastline of the British platform is represented as coinciding with the contour of 80 fathoms.

The strongest case for a cañon is undoubtedly the Fosse de Cap Breton at the head of the Gulf of Gascony, the leading bathymetrical features of which I have already briefly described. Here, as we know, the 100-fathom platform is cut through to a depth of 600 fathoms; and if this be due to ordinary river erosion consequent on emergence, it implies an elevation of between 3,000 and 4,000 feet at this particular place. It is singular that this well-marked 'fosse' should occur almost exactly in the angle formed by the French and Spanish shores of the Bay of Biscay. If it be really due to river action it may represent the effects of the accumulated waters draining the northern slopes of the Pyrenees. It must not be forgotten, however, that the south-west of France represents a Tertiary basin, and that throughout the greater part of Tertiary time there must have been something like a connection between the Bay of Biscay and the Golfe du Lion, which has obviously formed the principal communication between the Mediterranean and the Atlantic. The difficulty is further complicated by the fact that both the Fosse de Cap Breton and its supposed prolongation opposite Bilbao are within the tectonic influences of the Pyreneo-Cantabrian chain, and therefore belong to a region of exceptional dynamic activity.

Conclusion.

This paper has already exceeded the intended length, and yet without my having completed the work originally contemplated. It is not altogether an easy task to alternate hydrographical facts with geological theories. Although not holding any particular theory myself, I am somewhat inclined to the belief that the larger features of the earth's crust, and particularly the ocean basins, may have been permanent within certain limits. The flanks of these great depressions are more correctly described as slopes rather than as escarpments; and these slopes are probably due to ancient and deep-seated tectonic causes, active in some places and quiescent for a time in others. The eastern margin of the North Atlantic basin presents, as regards activity of motion in the present day, a marked contrast to the eastern margin of the Pacific, where the mobile condition of the suboceanic slope, off the coasts of South America, is well known. This comparative stability, however, may not always have prevailed. Indeed, we may feel pretty sure that movements have occurred along this line throughout geological time, altogether independent of local eruptions of basalt, etc.

If I might venture to sum up the results of the views suggested in this paper, they would appear somewhat as follows:—

1. The true boundary of the North Atlantic basin on this side is not to be sought in the existing coastlines, but in the submerged slope which lies beyond the edge of the submerged platform.

2. The edge of the submerged platform appears to range from about 80 to 250 fathoms, the most notable deviation from the usual depth occurring in connection with the irregular bulge of submerged

land bordering the Porcupine bank, off the west of Ireland. But the 100-fathom line is found for long distances to coincide fairly well with that edge, beyond which the suboceanic slope plunges, sometimes gradually, sometimes sharply, into abyssal depths.

3. The suboceanic slope may be traced as a distinct feature, though better defined in some places than in others, with a general north-north-easterly trend, as far as off the north-west of Spitzbergen, where the trend becomes easterly in face of the North Polar ocean.

4. The suboceanic slope is to be regarded as the true limit between the continental area and the oceanic area, and the terrigenous deposits appear, throughout geological time, to have been confined to the region which lies within, i.e. to the eastward of, this line.

5. The great tectonic movements have been especially powerful in alignment with the suboceanic continental slope at different periods of the world's history ; and these movements have produced extensive protuberances, which have yielded no inconsiderable portion of the sediments deposited in the corresponding geosynclinal hollows, thus constituting some of the great terrigenous formations. The extensive development of old crystalline rocks in the countries which border the North Atlantic probably represent portions of these old protuberances.

6. Although the line dividing the continental from the oceanic area is fairly well defined throughout the region under consideration, it is one of unequal strength, and appears to fail or to be deeply deflected in certain places. Commencing on the north, the first great embayment is represented by the mouth of the Barents Sea. Here the coastline with its old crystalline rocks, of which there are said to be considerable traces in the west of Spitzbergen, fails us until we get to Norway. Similarly there is a great gap between Norway and Scotland, the intervening area being represented by the mouth of the North Sea. Both these embayments are occupied by shallow seas and their connections, and they may be regarded as belonging to the continental area and to share its vicissitudes. Yet it is probable that throughout a part, at least, of geological time they have been the gateways whereby the waters of the ocean communicated with the various seas, where deposits since elevated into dry land have from time to time been formed.

Omitting the mouth of the English Channel, which possibly has a different origin, the next great embayment is the Bay of Biscay, and this differs from the two previously mentioned by its great depth. This seems to represent the gateway, whereby the waters of the ocean communicated with the Mediterranean, though in the present day the head of the gulf has been filled up by the Tertiary deposits, which constitute so large a portion of the south-west of France. Moreover, this area is complicated by the great tectonic movements in connection with the Pyreneo-Cantabrian chain. The gut of Gibraltar is probably a more recent feature, and may in part be due to meteoric erosion at a time when the land was higher. This also may have been the case with the Fosse de Cap Breton.

7. In addition to the inferences stated under 6, it is obvious that extensive basaltic eruptions in certain portions of the North Atlantic depression have interfered with the regularity of the suboceanic continental slope. These are associated with terrigenous rocks on the continental side of the slope, but apparently not so on the oceanic side. Of the former case Franz Josef Land and the Hebrides supply noteworthy instances.

8. With respect to the amount of elevation undergone at various periods along the eastern margin of the North Atlantic basin, there are no very certain data. Speculation on this point should be confined within reasonable limits, and we ought to be content with the minimum divergence from present-day conditions which is required to account for the most obvious facts. Subsequent to the commencement of the Tertiary period, local changes to the extent of 500 fathoms would still leave the great depths unaffected, whilst there is no reason to believe that any changes to this extent have occurred in Pleistocene times. In Fig. 1 it will be seen that special prominence has been given to the 500-fathom line.

II.—On the Families of Sauropodous Dinosauria.[1]

By Professor O. C. Marsh, Ph.D., LL.D.

THE subclass Dinosauria, as known to-day, I have divided into three orders: the Theropoda, or carnivorous forms; the Sauropoda, or herbivorous quadrupedal forms; and the Predentata, also herbivorous, and including several suborders, namely, the Stegosauria and Ceratopsia, both quadrupedal, and the Ornithopoda, containing bipedal bird-like reptiles.[2]

The principal characters of the order Sauropoda, here discussed, may be briefly stated as follows:—

Order SAUROPODA.

External nares at top of skull; premaxillary bones with teeth; crowns of teeth rugose, and more or less spoon-shaped; large antorbital openings; no pineal foramen; alisphenoid bones; brain-case ossified; no columellæ; postoccipital bones; no predentary bone; dentary without coronoid process. Cervical ribs co-ossified with vertebræ; anterior vertebræ opisthocœlian, with neural spines bifid; posterior trunk vertebræ united by diplosphenal articulation; presacral vertebræ hollow; each sacral vertebra supports its own sacral rib, or transverse process; no diapophyses on sacral vertebræ; neural canal much expanded in sacrum; first caudal vertebra biconvex; anterior caudals procœlian. Sternal bones parial; sternal ribs ossified. Ilium expanded in front of acetabulum; pubes projecting in front, and united distally by cartilage; no post-pubis. Limb bones solid; fore and hind limbs nearly equal; metacarpals longer than metatarsals; femur longer than tibia; astragalus and calcaneum not fitted to end of tibia; feet plantigrade, ungulate; five

[1] Abstract of communication made to Section D, British Association for the Advancement of Science, Bristol Meeting, September 12, 1898.

[2] The Dinosaurs of North America, Sixteenth Annual Report, U.S. Geological Survey. 84 plates. Washington, 1896.

digits in manus and pes; second row of carpal and tarsal bones unossified; locomotion quadrupedal.

(1) Family Atlantosauridæ. A pituitary canal; large fossa for nasal gland. Distal end of scapula not expanded; coracoid quadrilateral. Sacrum hollow; ischia directed downward, with expanded extremities meeting on median line. Anterior caudal vertebræ short, with lateral cavities; remaining caudals solid; chevrons single.

Genera *Atlantosaurus*, *Apatosaurus*, *Brontosaurus* include the largest known land animals. Jurassic, North America.

(2) Family Diplodocidæ. External nares at apex of skull; no depression for nasal gland; two antorbital openings; large pituitary fossa; dentition weak, and in front of jaws only; brain inclined backward; dentary bone narrow in front. Scapula with shaft somewhat enlarged at summit. Ischia with shaft expanded distally, directed downward and backward, with sides meeting on median line. Sacrum hollow, with three co-ossified vertebræ. Anterior caudal vertebræ procœlian, with sides deeply excavated, and chevrons single; median caudals excavated below, with chevrons double, having both anterior and posterior branches; distal caudals elongate, with rod-like chevrons.

Genera *Diplodocus* and *Barosaurus*. Jurassic, North America.

(3) Family Morosauridæ. External nares anterior; large fossa for nasal gland; small pituitary fossa; dentary bone massive in front; teeth very large. Shaft of scapula expanded at distal end; coracoid suboval. Sacral vertebræ four in number, and nearly solid; ischia slender, with twisted shaft directed backward, and sides meeting on median line. Anterior caudals solid; chevrons single.

Genera *Morosaurus*, *Camarasaurus* (?) (Amphicœlias). Jurassic, North America and Europe.

(4) Family Pleurocœlidæ. Dentary bone constricted medially; teeth with crowns like those of *Diplodocus*. Cervical vertebræ elongate, centra hollow, with large lateral openings; sacral vertebræ solid; with lateral depressions in centra; caudal vertebræ solid; anterior caudals with flat articular faces, and transversely compressed neural spines; median caudal vertebræ with neural arches on front half of centra. Ischia with compressed distal ends, and sides meeting on median line.

Genera *Pleurocœlus*, *Astrodon* (?). Jurassic, North America and Europe. Include the smallest known Sauropoda.

(5) Family Cardiodontidæ. Teeth of moderate size. Upper end of scapula expanded; humerus elongate; fore limbs nearly equalling hind limbs in length. Sacrum solid; ischia with wide distal ends, and sides meeting on median line. Caudal vertebræ biconcave; median caudals with double chevrons.

Genera *Cardiodon* (Cetiosaurus), *Bothriospondylus*, *Ornithopsis*, and *Pelorosaurus*. European, and probably all Jurassic.

(6) Family Titanosauridæ. Fore limbs elongate; coracoid quadrilateral. Presacral vertebræ opisthocœlian; first caudal vertebræ biconvex; remaining caudals procœlian; chevrons open above.

Genera *Titanosaurus* and *Argyrosaurus*. Cretaceous (?), India and Patagonia.

III.—The Base of the Gault in Eastern England.

By A. M. Davies, A.R.C.S., B.Sc., F.G.S.

In a paper published in this Magazine in March, 1895,[1] Dr. J. W. Gregory, incidentally discussing the exact age of the base of the Gault Clay, wrote: "*Hoplites interruptus* seems restricted in [Eastern] England to the Folkestone area and the Red Chalk." Although some of his conclusions on that point were modified later,[2] the general statement quoted above, with the qualification indicated by the bracketed word 'Eastern,' does not seem to have been challenged. Having myself found *H. interruptus* at the base of the Gault at several places in Eastern England, I have been led to look up previous records, with the result that I am convinced that the zone of *H. interruptus* is represented in the lowest beds of the Gault Clay over a large part of that area.

Taking first the Gault outcrop south of the North Downs, the following table shows the localities from which this fossil has been recorded, in order from east to west, and the distances between them:—

Locality.	Authorities.	Notes.
Folkestone.	*Omnes passim.*	
19 miles.		
Leacon Hill, 2 miles S. of Charing.	Fitton, Trans. Geol. Soc., ser. II, vol. iv, p. 112.	'*Amm. dentatus.*' For locality see also T. R. Jones, Geol. Mag., Dec. II, Vol. III (1876), p. 118.
17 miles.		
Aylesford and Maidstone district.	De Rance in Topley's "Weald Memoir."	
13 miles.		
St. John's Brickyard, between Sevenoaks and Otford.	A. M. D.	*H. splendens* also.
4½ miles.		
Westerham.	Fitton, loc. cit., p. 152.	'*Amm. dentatus*' in Gault Clay. Specimen in Geol. Soc. Museum.
9½ miles.		
Battlebridge, near Merstham.	Whitaker & Hinde, Proc. Geol. Assoc., vol. xv, p. 114.	
9½ miles.		
Westcott, near Dorking.	Leighton, Proc. Geol. Assoc., vol. xiii, p. 9.	At base of Gault.
20 miles.		
Wracclesham, near Farnham.	Monckton, ibid., p. 76.	In sandy beds, four or five feet below base of clay.
4 (?) miles.		
Railway cutting "near Alton."	Bristow & Whitaker, "Geology of parts of Berks and Hants": Mem. Geol. Surv., Sheet 12, p. 4.	*Acanthoceras mammillatum*, *Hoplites lautus*, and *H. tuberculatus* recorded also. All from Gault; no details.

[1] "Fossils from Lower Greensand of Great Chart": Geol. Mag., Dec. IV, Vol. II, p. 97.

[2] Ibid., pp. 187-9.

In all these cases, the fossils clearly came from either the actual base of the Gault, or from Gault Clay not far above Lower Greensand, except in the case of the last but one, and possibly the last. The gaps of 20 miles, without a record, simply indicate stretches of outcrop where exposures are few. The conclusion seems inevitable that along the outcrop from Folkestone, at least to Dorking, the lithological change from 'Lower Greensand' to 'Gault' represents a constant time-level, though farther west this may perhaps cease to be the case.

Let us next take the northern outcrop from Norfolk to Berkshire:

Locality.	Authorities.	Notes.
Hunstanton.	Wiltshire, "Red Chalk of England," p. 17.	'*Amm. serratus*' in Red Chalk.
6½ miles.		
Ingoldsthorpe.	Fitton, loc. cit., p. 316.	In grey sandy clay. '*Amm. dentatus*.'
20 miles.		
West Dereham.	Jukes-Browne & Hill, Quart. Journ. Geol. Soc., vol. xliii, p. 571.	
19 miles.		
Upware.	Keeping, Geol. Mag., Dec. I, Vol. V (1868), p. 272.	Base of Gault.
7 miles.		
Between Landbeach and Cottenham.	Penning & Jukes-Browne, "Geology of the Neighbourhood of Cambridge": Mem. Geol. Surv., Sh. 51 (S.W. and N.W.), p. 19.	
9 miles.		
Haslingfield.	Ibid., p. 17.	
19 miles.		
Campton, near Shefford.	Price, "The Gault" (London, 1879), p. 29.	
14 miles.		
Heath, N. of Leighton Buzzard.	A. M. D.	Base of Gault. With *H. tuberculatus* and *Schlönbachia inflata*. (See below.)
19½ miles.		
Thame (brickfield between Railway Station and Thame Park).	A. M. D.	Base of Gault. (See below.)
14 miles.		
Culham.	Phillips, Quart. Journ. Geol. Soc., vol. xvi, p. 307.	Base of Gault. '*Amm. dentatus*.'
38 miles to Devizes.		

The specimens from Heath were found in Mr. Bushell's old pit, visited by the Geologists' Association in 1897[1] under the guidance of Mr. A. C. G. Cameron. As I understand that the pit will soon be closed over, it may be well to give a full list

[1] Proc. Geol. Assoc., vol. xv, p. 184.

of fossils from it. These were in part collected by my wife on the visit of the Geologists' Association, partly by myself on a later occasion. All except the belemnites are phosphatized.

Hoplites interruptus.
H. tuberculatus.
H. lautus (?) (a worn fragment).
Schlönbachia inflata.
Belemnites minimus (abundant).
Solarium.
Dentalium.
Inoceramus concentricus.
I. sulcatus.
Fish-scales.
Fish-coprolites.

The mixture of Upper and Lower Gault fossils is striking, but has been noted already for this district by Mr. Jukes-Browne [1] and also appears to exist in the Isle of Wight, where *S. inflata* occurs in the Gault Clay along with *H. interruptus*, as well as ranging through the Malm and Chert beds above.[2] I should, however, add that some thickness of Gault is exposed at Heath (at least fifteen feet, speaking from memory), and that owing to the large extent of slip no fossils could be obtained actually in place, so that some may have come from a higher zone than others.

At Thame the actual junction of Gault and 'Lower Greensand' (here probably of fresh-water origin) is not seen, but the two are dug in shallow pits not many yards apart. The fossils I obtained here were—

Hoplites interruptus,
Belemnites minimus,

and the following Foraminifera:—

Cristellaria gibba, D'Orb.
C. subalata, Reuss.
C. gaultina, Berthelin.
Pulvinulina spinulifera (Reuss).

Another Gault-pit, a mile and a quarter farther west, where the Shillingford Road crosses the railway, is absolutely unfossiliferous, even foraminifera being unobtainable.

On the outlier at Long Crendon, $2\frac{3}{4}$ miles to the north-west, the base of the Gault is clearly exposed, but here I failed to find Ammonites, though foraminifera were plentiful.

In the 38 miles between Culham and Devizes, the Gault appears to be very unfossiliferous. When the Geologists' Association visited Faringdon in 1877, Mr. E. C. Davey published a catalogue [3] in order, as he states, "to vindicate the palæontological honour of Berkshire." He complained that "the Government Surveyors have not recorded a single specimen from either Gault or Upper Greensand," and "the late Professor Philips is equally silent." Nevertheless he was himself only able to give six genera (without species) for the Gault. There are therefore no data available, so far as I am aware, for fixing the exact age of the base of the Gault between Culham and the Devizes district.

[1] "Handbook of Historical Geology," p. 412.
[2] Reid & Strahan, "Geology of the Isle of Wight."
[3] "Catalogue of Fossils from the Cretaceous Beds of Berkshire, in the Collection of E. C. Davey, F.G.S." (Wantage, 1877).

It is clear, however, that from the first coming-in of Gault Clay in Norfolk to its last fossiliferous exposure on the banks of the Thames, wherever its basal zone can be recognized it is that of *Hoplites interruptus*.

If we now turn to the underground distribution of the Gault in the area between the two outcrops we have been considering, we find that the Gault, taken as a whole, is continuous under the entire district so far as the evidence goes. It varies greatly in thickness, but if we plot out all the borings on a map and sketch out lines of equal thickness between them, we find that, in spite of many irregularities, these lines have a general N.W.–S.E. trend, and indicate a north-easterly thinning, which becomes strikingly manifest at Weeley, Stutton, and Harwich. As this north-easterly thinning is accompanied by disappearance of the Lower Greensand, it is due probably to overlap, and not to erosion of the Upper Gault like the northerly thinning along the outcrop. There is, therefore, an *a priori* probability that the lower zones of the Gault as we pass to the north-east first take on a shallow-water facies (which would be called 'Lower Greensand') and then are overlapped altogether. But so many different circumstances combine in affecting the thickness of a deposit that it is not safe to base any definite conclusions on it alone. From only one of the borings in this area have fossils been recorded which could help in the determination of the basal zone of the Gault, and that is the Richmond boring. Dr. Gregory has discussed[1] the evidence from this boring, and concludes that it is in favour of the absence of the *H. interruptus* zone.

After pointing out that *H. splendens* occurred both at 1,100 and at 1,128 feet depth, he says: "This species ranges from the 4th to the 7th zone of the Gault. If we make the somewhat improbable assumption that this [the lower] specimen came from the very lowest possible point at which it could have occurred, then zones 1–3 are reduced to a thickness of only 13 feet. Thus, either the three basal zones are proportionally much thinner at Richmond than they are at Folkestone, or else one or more of them is there absent. The latter view appears the more probable."

I am afraid this argument will not stand a close examination. It is true that in the Weald Memoir the range of *H. splendens* is given as zones 4–9 (not 7), but Price records it from his zones 2–8,[2] answering to De Rance's 3–8. Combining the two, we find the maximum range to be through about 27 feet, starting at 10 feet from the bottom. At Richmond the two specimens were 28 feet apart, and the lower one 13 feet from the bottom—a curiously close approximation to the Folkestone range. Moreover, *H. splendens* is not so restricted everywhere as at Folkestone. I have found it along with *H. interruptus* at St. John's, near Sevenoaks, and Mr. R. B. Newton has recorded it from the *interruptus*-zone of

[1] Loc. cit., p. 101.
[2] Quart. Journ. Geol. Soc., vol. xxx, p. 342.

Okeford Fitzpaine, Dorset.[1] The proof which it was supposed to give of the absence of that zone at Richmond consequently falls to the ground.

In conclusion, I have to express my sincere thanks to Mr. G. C. Crick for his ever ready help to me in the identification of Cephalopods; to Mr. F. Chapman for identifying the foraminifera; and to Dr. Hinde for kindly sending me the fossils collected at Battlebridge to examine.

NOTICES OF MEMOIRS.

NOTES ON ROCKALL ISLAND AND BANK. With an Account of the Petrology of Rockall, and of its Winds, Currents, etc.; with Reports on the Ornithology, the Invertebrate Fauna of the Bank, and on its previous History. Transactions of the Royal Irish Academy, vol. xxxi (1897), pt. 3, pp. 39–98, with plates ix–xiv.

THIS memoir contains the results of an exploration carried on under the direction of the Rev. W. Spotswood Green, of the Irish Fisheries Board, with the assistance of Mr. Harvie Brown, Mr. R. M. Barrington, and a committee of the Royal Irish Academy. In June, 1896, the s.s. "Granuaile," of the Congested Districts Board, made two visits to the Rockall Bank, but none of the party of naturalists on board of her were able to effect a landing upon Rockall itself, though some interesting sketches and photographs were made of it, and valuable collections obtained from the surrounding seas.

The Rockall Bank is situated in the Mid-Atlantic, and it is separated from the plateau on which the British Islands stand by seas having a depth of from 1,300 to 1,600 fathoms. The bank is 150 miles long from N.E. to S.W., by about 50 miles wide, within the 200-fathom line, and about half that extent within the 100-fathom line; it is resorted to by fishing-craft at certain seasons, but the amount of fishing carried on there has not been so great as was at one time anticipated.

Rockall itself, which is situated in lat. 57° 36′ N., long. 13° 42′ W., is said by Captain Basil Hall to be "the most isolated speck of rock in the world." It is 240 miles distant from the Irish coast, 290 miles away from the nearest point of Scotland, and 170 miles from St. Kilda. It is only about 250 feet in circumference at its base, and about 70 feet in height. At a radius of $2\frac{1}{2}$ miles from the rock the depths are from 40 to 70 fathoms, but within this area two other small rocks rise nearly to the surface of the sea. 'Haslewood Rock' is a small half-tide detached rock, bearing N.E. by N. $1\frac{1}{2}$ cables from Rockall, and 'Helen's Reef' (so called from a vessel that was wrecked upon it) is $1\frac{3}{4}$ miles E. by S. from Rockall, and has about six feet of water upon it at low-water.

It has sometimes been suggested that Rockall might form an invaluable position to be utilized for a lighthouse or a meteorological

[1] GEOL. MAG., Dec. IV, Vol. III (1896), p. 200.

station. But minute as it is in size, and exposed as it is to the full swell of the Atlantic, which rises and falls there more than 12 feet in the calmest weather, such use of the rock appears to be out of the question. Indeed, fishermen and sailors from men-of-war have only occasionally effected a landing upon it, under the most favourable conditions, with the greatest difficulty. The rock lies out of any of the usual tracks followed by steamships and sailing vessels in crossing the Atlantic. At a distance it appears, with its dark-coloured base and top whitened with the dung of innumerable sea-fowl, so like a ship under full sail, that in war-time the captains of men-of-war are said to have been frequently deceived by it.

Although no landing was effected during the recent investigation of Rockall, the exploring party managed to secure a number of interesting drawings and photographs of the rock. The Rev. W. S. Green describes the general character of the mass in the following words :—"The east face seemed like a great slab of gray granitoid rock (and I was within 20 yards of it), with rectangular joints broken off at the north, so as to show the square edge of another slab, and this was in turn broken off, showing the face of a third." This granitoid mass "rests on a rock showing a kind of bedding or jointing (?), dipping about east, and at an angle of 30° or so."

So far as is known, no specimens have ever been obtained from this underlying mass on the west or south-west of the rock, and it is impossible to say whether it consists of sedimentary materials, of stratified tuffs, or of some fissile igneous rock.

Of the overlying granitoid mass, however, the relations of which seem to strikingly resemble those of an intrusive sheet, the indefatigable exertions of Professor T. Rupert Jones have resulted in bringing together three specimens. These have been submitted to Professor Judd for examination in the Geological Laboratories of the Royal College of Science. One of these specimens was obtained by Basil Hall as long ago as the year 1810, when Rockall was visited by H.M.S. "Endymion"; the others were obtained by Commander Hoskyn and Captain Inskip respectively, during the visit of H.M.S. "Porcupine" to the rock in 1862. In each case the specimens were obtained by an active sailor, with a line attached to him, springing from a boat on to the rock, and, when he had secured fragments of it, throwing himself into the sea to be towed back to the boat.

Two of the specimens were found on microscopic examination to be distinctly granitic in structure, the quartz, felspar, and augite of which they are made up being allotriomorphic. Their structure, however, resembles that of the granite-porphyries rather than that of the true granites. The third specimen, while made up of the same minerals, is distinctly hypocrystalline, having the kind of groundmass which Rosenbusch distinguishes as 'hypidomorphic.' This variety, having a darker colour, as well as a finer texture, may not improbably form veins, or possibly inclusions, in the main mass; or it may belong to the edge of the intrusive sheet. All the rocks are somewhat drusy or miarolitic in structure.

Detailed microscopical examination shows that the material of

Rockall is really of a very unique and interesting character. The rock consists of three minerals—a soda-augite (ægirine and acmite), quartz, and albite. Accessory minerals, other than magnetite and apatite, appear to be very rare in it. The proportion of these ingredients is somewhat different in the several examples of the rock, the darker-coloured variety containing more of the soda-augites.

The order of crystallization of the minerals of the rock is easily determined. The soda-augite (ægirine and acmite) was the first to separate, the centres of the crystals being grass-green ægirine, and the peripheral portion brown acmite, each mineral exhibiting its characteristic pleochroism. After the augite, albite separated, and the quartz crystallized out last.

Apatite needles are found enclosed in all the minerals of the rock, and among the secondary minerals of the rock are magnetite, quartz, arfvedsonite, and a blue soda-amphibole.

The specific gravities of different specimens determined by Mr. H. S. Hinton, F.G.S., were found to vary from 2·71 to 2·94.

An analysis of the rock of the highest specific gravity and darkest colour, which was made by Mr. C. J. S. Makins, under the superintendence of Professor W. A. Tilden, gave the following result :—

Silica	73·60
Alumina	4·70
Ferric Oxide	13·10
Manganese Oxide	·93
Nickel Oxide	·06
Magnesia	·11
Lime	·37
Soda	6·96
Potash	minute trace
Phosphoric Acid	traces
	99·83

This analysis shows the mineralogical constitution of the rock to be as follows :—

Ægirine and Acmite	39 per cent.
Quartz	38 ,,
Albite	23 ,,
(With a little anorthite.)	

The soda-augite (ægirine and acmite) appear to have a very similar composition to that of the rocks of the Christiania district described by Brögger, while the bulk analysis of the rock resembles that of some of the quartz ceratophyres and some of the quartz-pantellerites of Foerstner.

The nearest analogues of the rock of Rockall are to be found among the grorudites of Brögger (quartz-tinguaite of Rosenbusch). Professor Brögger, who has examined a section of the rock sent to him, agrees that the rock is similar to his grorudites in mineral composition, but he demurs to it being included under his name on account of the differences in structure. On the other hand, the rock of Rockall is shown to differ from the Natron-granites, some of which it resembles in structure, by its high proportion of augite.

Under these circumstances it is proposed to give to the material of Rockall a distinctive name and to call it 'Rockallite.'

Rockallite is defined as a rock having the structure of the 'granite-porphyries' but belonging to the extreme variety of the soda-bearing acid rocks. It is an ægirine-quartz-albite rock, intermediate in structure and composition between the soda-granites on the one hand and the grorudites on the other, and presenting points of analogy with some soda-ceratophyres. Among lavas or effusive rocks, rockallite is probably represented by some quartz-pantellerites.

With respect to the age and relations of the rock forming the singular isolated mass of Rockall, the materials for arriving at a judgment must be admitted to be very small. If the rock, on which the igneous mass lies and over which it appears to have been thrust, could be examined, and especially if this were shown to be a stratified rock with fossils, the evidence thus afforded would be of great value. At present, however, we have nothing but general analogies to guide us. The nearest resemblance to rockallite is found, as we have seen, among the Post-Silurian dykes in the Christiania district so admirably investigated by Professor Brögger; and it may be that in Rockall we have a similar intrusive mass of the same period that has escaped destruction by denudation. But it must be remembered that among the Tertiary rocks of the Western Isles of Scotland, in St. Kilda (which is the nearest land to Rockall), in Skye, Ardnamurchan, Mull, and Arran, we have granites and granite-porphyries containing soda-augites and soda-amphiboles. Some rocks, indeed, approaching in character to rockallite, occur among the Tertiary eruptives, and it is, therefore, by no means impossible that rockallite may belong to the same recent period.

In another division of the memoir before us, Professor Grenville A. J. Cole describes the rock-specimens dredged on the Rockall Bank. These all show a remarkable uniformity of character, as if the original source of the material had been true local rock-masses rather than any ice-drift.

The great mass of the specimens appears to be basalt of the ordinary type. Some of these appear to be destitute of olivine, and approximate to augite andesite or basalt andesite. Some are vesicular; others are more or less glassy in texture, and exhibit flow-structures. An andesitic pumice and a scoriaceous andesite, "well removed from the extreme basaltic types," were also found. With these igneous rocks was found one example of a fine-grained grey argillaceous and slightly micaceous sandstone, strikingly resembling the Ordovician sandstones in the altered strata of County Down.

Among specimens supplied by Mr. Cordeaux of Grimsby, and obtained by fishermen entangled in their lines when fishing on the Rockall Bank, are many basalts; also one specimen of an ordinary red granite with micro-pegmatite and a red sandstone, very similar to the Torridonian rocks.

Mr. R. H. Scott supplies to the memoir an account, illustrated by sketch charts, of the winds and currents in the district in which

Rockall occurs. The sources of information for these charts are the logs of Her Majesty's ships since 1830 and of vessels in the Mercantile Marine since 1854.

Mr. H. N. Dickson, of the Chemical Laboratory, University Museum, Oxford, gives the results of a series of analyses by which the degree of salinity of a number of samples of sea-water collected off Rockall was determined.

The memoir concludes with a series of Reports on the Natural History of Rockall and the surrounding seas. That on the Ornithology is by Mr. J. A. Harvie Brown; that on the Mollusca by Mr. A. R. Nichols, of the Science and Art Museum, Dublin; that on the Crustacea by Mr. W. T. Calman, B.Sc., and Professor E. P. Wright; that on the Chætopoda by Professor M'Intosh; that on the Echinodermata by Mr. W. P. Sladen; that on the Polyzoa by Miss L. R. Thornelly; and that on the Sponges by Professor R. von Lendenfeld.

Professor T. Rupert Jones, who has been untiring in his efforts to obtain new light on this most interesting locality, contributes a very valuable sketch of the previous history of Rockall, and a general epitome of all that has hitherto been published concerning it.

The memoir is well illustrated by three coloured drawings of Rockall from sketches by the Rev. W. S. Green; six photographs of the rock taken from different directions; a beautiful plate, showing the characters of the two types of 'rockallite' as seen in thin slices under the microscope, drawn by the skilful hand of Mrs. Cole; and twelve charts showing the directions of currents around Rockall during every month of the year.

The Royal Irish Academy is to be congratulated upon their spirited attempt to gain new light upon this interesting locality, and no less so on the manner in which the results achieved have been presented to the public in their 'Transactions.'

REVIEWS.

I.—Memoirs of the Geological Survey of England and Wales. "The Geology of the Isle of Purbeck and Weymouth." By Aubrey Strahan, M.A., F.G.S. 8vo: pp. xi and 278; 5 plates from photographs, 2 folding plates, and 183 other illustrations in the text; map and 3 plates of sections at the end of the book. (London, 1898. Price 10*s.* 6*d.*)

IN his preface the Director-General of the Geological Survey remarks that "when the revision of the Geological Survey maps of the Isle of Wight was completed in 1888, it was deemed advisable to continue the work into the adjacent parts of Dorset. The task of resurveying the classic Isle of Purbeck and the region round Weymouth was entrusted to Mr. A. Strahan, who had mapped the Secondary formations of the Isle of Wight. In two years the field-work was finished as far as the top of the Chalk, and the mapping of the Tertiary deposits was subsequently completed by Mr. C. Reid."

Quite recently also five new sheets of this district, based upon a new series of Ordnance Survey maps, have been issued coloured geologically; and thus both the topography and geology of the district have been rectified and brought up to date. Manuscript copies of the original six-inch working maps are to be seen at the Museum of Practical Geology.

So far as the Jurassic portion of this work is concerned, it is to a considerable extent a reissue of that part of Mr. H. B. Woodward's memoir on the Middle and Upper Jurassic rocks of England (vol. v of the "Jurassic Rocks of Britain") relating to this district. Mr. Woodward's work was reviewed in the GEOLOGICAL MAGAZINE for 1896,[1] when we had occasion to comment unfavourably on the printing of some of the illustrations. Mr. Strahan has been more fortunate in having his memoir on the Isle of Purbeck better treated by the Stationery Office, so that the same figures of Jurassic fossils, which were so indistinctly printed in Mr. Woodward's memoir, come out much better in the Isle of Purbeck memoir, and this remark also applies to other illustrations repeated from Mr. Woodward's book. The new illustrations in Mr. Strahan's work (many of them being prints from photogravures) and the folding plates with coloured sections are exceedingly good. But, then, we must bear in mind that the price of this memoir, containing 278 pages, is 10*s.* 6*d.*, as against 7*s.* 6*d.* for vol. v of the "Jurassic Rocks of Britain," with its 449 pages.

We quite agree with the author that the district under consideration includes a length of coast which is hardly surpassed in interest in any other part of England. This interest may be said to culminate in the various coves, etc., about Lulworth, "which furnish an example of coast erosion that cannot easily be matched elsewhere." Stair Hole and Lulworth Cove are illustrated by the frontispiece, which has been reproduced from a photograph by Mr. Mason Good. Geologists are to be congratulated that this piece of coast is dissected by the sea in such a manner as to display stratigraphical features of the utmost importance—Alpine sections, one might almost say, in miniature. A few æons further back in time the progress of erosion would not have been sufficiently advanced to show these things well: a few æons later, if there are no material alterations in the level, and most of the phenomena in connection with the Isle of Purbeck disturbance at Lulworth will have disappeared, whilst the sea will merely wash cliffs of chalk having a dip of a few degrees to the northwards.

Under the heading of Purbeck Beds a considerable amount of fresh matter is introduced, though the chapter on Organic Remains is mainly derived from Mr. Woodward's memoir, with the same figures of fossils somewhat better printed. A similar remark applies also to such cuts as the diagram-section of part of Stair Hole, the silicified mass of Purbeck wood at Portisham, and others.

[1] Dec. IV, Vol. III, p. 129.

The author is considerably exercised as to the question on what horizon the boundary should be drawn between the Jurassic and Cretaceous systems. "Without attempting," says the Director-General, "to decide this stratigraphical question in what is intended to be a local memoir, Mr. Strahan has laid stress on the classification which, though local, represents most naturally the relations of the rock-groups to each other in the South of England." We perceive that, whilst the base of the Purbecks is entirely distinct from the underlying Portland Beds, there is a difficulty in separating the former from the Wealden Series, whether palæontologically or stratigraphically; moreover, in this area the Wealden folds with the Jurassics. On the other hand, as fresh-water conditions were continued, no matter what the period may have been, the Wealden waters had no chance of receiving any accession of the neighbouring marine fauna, which in other regions was already assuming a Cretaceous type. Although there may be a difficulty in separating them, yet a very marked difference exists between the Lower and Middle Purbecks and the Wealden taken as a whole. The Purbecks consist largely of calcareous beds, and the area was liable to sudden incursions of the sea, which restored for a time a semi-marine fauna: the Wealden, on the contrary, is very poor in calcareous matter, and the deposits are more essentially fluviatile.

Mr. Strahan expresses his views in the following table (p. 76) :—

Formations, South of England.	Conditions of Deposition.	Affinities.	Equivalents in the North of England.
Chalk. Upper Greensand and Gault.	Wholly marine.	Cretaceous.	Chalk. Red Chalk and Carstone.
Break.	—		*Break.*
Lower Greensand.	Wholly marine.	Cretaceous.	Tealby Series and Spilsby Sandstone; a stratigraphically continuous series of marine deposits with Oolitic affinities in the lower part.
Palæontological break due to sudden change of conditions.			
Wealden. Purbeck.	Estuarine marine alternating with and passing down into fresh-water and terrestrial.	Oolitic as relates to the plants, reptiles, & marine molluscs.	
	—	—	*Break.*
Palæontological break due to sudden change of conditions.			
Portlandian. Kimmeridgian, etc.	Wholly marine.	Oolitic.	Kimmeridgian, etc.

Of the many curious features which the Lower Purbeck present, that of 'brecciation' has caused not a little difference of opinion. Mr. Strahan is inclined to support the view propounded by the Rev. O. Fisher, that the fracturing of the 'broken beds' was due to their having been deposited over a mass of decaying trees and mosses and having subsequently fallen in. Plate iii gives a good representation of the 'broken beds' near Lulworth, and may also be taken generally as a favourable specimen of the application of photography to stratigraphical features.

The Wealden Beds in this area are not particularly interesting from a palæontological point of view, though at Worbarrow Bay their total thickness is stated to be 1,237 feet, the formation becoming thinner westwards. The Lower Greensand is exposed in three coast sections, viz., at Punfield Cove in Swanage Bay, in Worbarrow Bay, and in Mupe Bay, westward of which it thins out. As already determined in the "Geology of the Isle of Wight," the author accepts Mr. Meyer's opinion that the Punfield Beds of the Isle of Purbeck are Lower Greensand; he states also that the subdivisions of the Isle of Wight, though greatly attenuated, are partly recognizable at Punfield, where the total thickness is 198 feet. At Worbarrow Bay the section shows 136 feet, and the beds are less fossiliferous. Of the few inland exposures of Lower Greensand the Corfe Castle cutting alone exhibited any points of interest.

The Gault and Upper Greensand, owing to a change in the character of the former, are not to be separated within the district. Like the rest of the Cretaceous rocks, the Gault and Greensand are thinner in Purbeck than in the Isle of Wight, but unlike the others they thicken again further west. Palæontologically, these strata are divided by Dr. Barrois into the zones of *Pecten asper* and *Ammonites inflatus*, but the lithology does not quite correspond with the zoning. At Worbarrow Bay this formation is 167 feet thick. A fine series of fossils appears to have been collected by Barrois from the Upper Greensand of Durdle and Lulworth.

The Chalk, being one of the most important formations within the area, is dealt with at considerable length, and the figures of fossils are rather more successful than has been the case in some of the previous memoirs. Dr. Barrois' palæontological zones of the Chalk of South Dorset are given in a table (p. 166), and on the following page Mr. Strahan gives us his latest views on the subdivisions of the Chalk as displayed in Ballard Cliff:—

		Ft.	in.
Upper Chalk.	Chalk with flints		
	Massive but somewhat lumpy chalk, without flints	20	0
	Chalk Rock: a layer of very hard green-coated nodules ...	0	4
Middle Chalk.	Hard, rough, and lumpy chalk	6	0
	Smooth, thick-bedded chalk, with partings of marl	90	0
	Melbourne Rock; rough, nodular, and flaky chalk, with sparry joints	6	0

		Ft.	in.
Lower Chalk.	Zone of *Belemnitella plena*: Smooth chalk with conchoidal fracture and five partings of pale-blue marl ...	4	0
	Zone of *Belemnitella plena*: Smooth chalk, passing into	2	0
	Zone of *Belemnitella plena*: Fine marl	5	0
	Alternations of chalk and marl in bands of 1 to 2 feet in thickness: an occasional line of green nodules, like those of the Chalk Rock. *Ammonites varians* occurs in the lower 22 feet, but not above	126	0
	Hard chalk-marl weathering into rhombs	6	0
	Very hard splintery chalk	1	4
	Sandy and glauconitic marl	0	10
	Chloritic marl; glauconitic sand with rolled casts of *Ammonites*, *Nautili*, and *Exogyræ*, the last apparently indigenous	4	0

The westward attenuation of the Chalk is a noteworthy feature, as shown in the following table (p. 164) :—

	Ballard Point.	Worbarrow, Lulworth, and White Nothe.	Black Down and westwards.
	ft.	ft.	ft.
Upper Chalk.	1,049	956	300–500 [1]
Middle Chalk.	102	113–90	100–150
Lower Chalk.	149	114–104	

The fine features presented by the Chalk in the coast sections are well illustrated, including the classical section of the Isle of Purbeck fault on Ballard Cliff. These will be more appropriately noticed under the heading "Disturbances and Faults."

The full description of the Tertiary strata of the Hampshire Basin is reserved for another memoir, but a few notes on occurrences in this district are given, and these have been partly furnished by Mr. C. Reid. Bearing in mind that the most important industry of the northern half of the Isle of Purbeck is especially connected with the Bagshot Beds, which cover nearly half the area of the map, plate viii, any evidence as to their physical history cannot fail to be of interest. Westwards they are said to become very gravelly, and they have been found to cut through the London Clay so as to rest directly on the Chalk. These gravels may be distinguished from those of the Reading Beds by their containing, in addition to flint and chert, so much quartz and subangular Palæozoic rocks "as to make the fine-screened material look like a Cornish beach." The history of the outliers on Bincombe Down and on Blackdown, near Portisham, is very remarkable; and Mr. Strahan considers that the Bagshots on the former hill have been partly affected by the Ridgway fault "tilting up the south side of the Bincombe outlier, but leaving the northern half horizontal." Formerly these outliers were regarded as Reading Beds by the Geological Survey, and as Plateau gravel by Prestwich.

The subject of Pleistocene and Recent deposits also comes in for a fair share of notice; and here the author, *apropos* of the

[1] A variable thickness of Chalk is missing here.

gravels of Portland Island, is led to take exception to the "interesting but erroneous speculation of Prestwich as to the age of the great topographical features of the district." The Broadway anticline, for instance, was of earlier age than supposed by Prestwich, "for its crest was planed off before the Upper Greensand was deposited." Of course, no work on the Weymouth district would be complete without a dissertation on the Chesil Beach, speculations as to the origin of which have given rise, he says, to a voluminous literature. To us it always seemed that the papers written by Sir John Coode in 1853 are by far the most valuable contributions to the subject. But the suggestion of the possible derivation of the quartzites and other far-travelled stones of doubtful origin from the destruction of the Plateau gravels of the more immediate district is one worthy of attention.

Probably the most important part of this memoir is that dealing with faults and disturbances. Ever since the days of Webster and Sir Henry Englefield, in the early years of this century, the coast-sections of East Dorset, in continuation of those of the Isle of Wight, have attracted the attention alike of artists and stratigraphists. We are favoured with a new interpretation of the origin of the phenomena which are so conspicuously displayed in Ballard Cliff, where the Isle of Purbeck fault first comes under notice (see plate iv). The same explanation is also held applicable further westwards, viz., the horizontal thrust movement, whereby the Chalk has been ruptured and pushed over itself, in a manner not unlike that displayed by the thrust-planes of the North-West Highlands.

Evidence is also adduced to show that the several disturbances are referable to different periods. The *post-Cretaceous* movements are thought to indicate three steps—

1. Between Chalk and Eocene.
2. Between Lower and Middle Eocene.
3. Miocene and early Pliocene.

Of course, it goes without saying that the denudation consequent on the upheaval of the Chalk must have been progressing for ages before any Eocene beds were laid down in this part of the world, since Chalk-flints had been churned into pebbles on many a shingle bank as the waste went on, and these same pebbles form no inconsiderable portion of the Lower Tertiaries all over the South of England. The movements between Lower and Middle Eocene seem to be more special to their district. Then came the folding of the Miocene age, to which the bulk of the phenomena may be ascribed. The *pre-Cretaceous*, or, as Mr. Strahan calls them, the *intra-Cretaceous*, movements, which do not affect the beds above the Gault-Greensand, have already been mentioned in connection with the Weymouth district.

Though the Isle of Purbeck fault intersects the cliff again west of Lulworth, its form is clearly shown in Ballard Point

only. Nevertheless, this disturbance produces results equally interesting on the Lulworth coast, where a region of compression occurs, as shown more especially by the squeezing and contortion of the Purbeck beds on the east side of Lulworth Cove, at Stair Hole, and other places. Plate v gives a good illustration of crushed and inverted Chalk-with-flints in Man O' War Cove. Here, the author says, we must conclude that the Middle and Lower Chalk, the Upper Greensand and Gault, and the Wealden and Purbeck Beds have suffered compression to the amount of one-fourth their original thickness. The other disturbances of post-Cretaceous age, and more especially the Ridgway fault, come in for their fair share of notice; whilst the remarkable phenomena observed in the Ridgway cutting, where Oxford Clay appears in the most unexpected manner, are duly discussed.

As regards illustrations for these important features, Mr. Strahan reintroduces his previously published map showing the intra-Cretaceous and post-Cretaceous disturbances, together with his previously published sections across the Purbeck and Ridgway faults. Three folding plates of sections, coloured geologically, further serve to display the marvels of the coast of East Dorset. These are drawn along or transverse to the coast by Mr. Strahan, and reduced from the original drawing by Mr. Gilbert Williams; the scale adopted is 12 inches to 1 mile, vertical and horizontal. It would be interesting to make a coasting voyage in order to compare these sections with Webster's bold drawings in Sir H. Englefield's work.

Chapters on physical and economic geology conclude this memoir, which is, moreover, provided with an exhaustive bibliography of some 25 pages on the "Geology, Mineralogy, and Palæontology of Dorset," the joint work of the author and Mr. Whitaker. The copious literature proves the interest which has been taken in this part of the world, and there can be no doubt that the volume under consideration is a most valuable addition to the general stock. Apart also from its value in a scientific sense, and as an indispensable addition to the library of all who take an interest in Dorset geology, it is more creditable to the Stationery Office than many of the memoirs which have been published by the Geological Survey.

II.—On Jurassic, Neocomian, and Gault Boulders found in Denmark. By Ethel G. Skeat and Victor Madsen. Large 8vo; pp. 213, with 8 plates of fossils and map. (Copenhagen: Reitzel, 1898.)

THIS work relates to the investigation of the fossil contents of a number of boulders of Mesozoic rocks, which are found associated with boulders of crystalline rocks in various parts of Jutland and the adjacent islands. The authors acknowledge the assistance they have received from various quarters; the material having been placed at their disposal by the General Direction of the Danish Geological Survey and other departments in Copenhagen. Their work was also greatly facilitated by assistance and advice

from Professor Zittel at Munich; and facilities were afforded for comparing the various species with type-specimens in several museums throughout England, France, and Switzerland.

In additon to the introduction the work consists of two parts: (1) a description of the boulders themselves and the conclusions arrived at as to their age and origin; (2) a palæontological part, consisting of notes and descriptions of the principal species contained in the boulders. Throughout the work great care has been taken to exhibit the ranges both in time and space of the several species, mostly lamellibranchs, on which the identification of the age of the boulders is based.

The oldest Mesozoic rock of which evidence exists is represented by boulders of varying materials, in which the shells are both fresh and brackish water forms, unfortunately but ill preserved. These are regarded as having been derived from Rhætic-Lias beds, which are not yet known. All three stages of the Lias are represented, one boulder from the *Jamesoni*-zone being quite a little museum in itself. These Lias boulders are found principally on the islands and on the east side of Jutland. They are regarded as having been derived from the eastward; and the same direction is also claimed for the one Callovian boulder which contains a recognizable *Macrocephalites*. The authors do not fail to enlarge upon the wide extent of this well-known Jurassic horizon.

By far the most numerous collection of fossiliferous boulders occurs in the extreme north-west of Jutland, where a Kimeridge-Portland fauna of the Swindon and Hartwell type is well represented. It is considered that these have been derived from beds now concealed in the Skagerrack. The matrix is mostly a calcareous sandstone, more or less ferruginous; and we can easily believe that anything like typical Kimeridge Clay would hardly survive in a boulder deposit. The Upper Jurassic, as we know, is found in strips along the east coast of Sutherland and Cromarty, almost opposite Jutland on the other side of the North Sea, where the general assemblage of fossils is said to give evidence of littoral conditions. "Fragments of the grits and limestones of the Upper Oolite, containing their characteristic fossils, are by no means rare in the Boulder-clay of Elginshire, and have also been detected in Aberdeenshire and Caithness" (Judd, in Q.J.G.S., vol. xxix, p. 184). Thus, on both sides of the North Sea there are evidences of a considerable development of beds of Upper Oolite age; although, if the fossils from the Scotch beds have been correctly determined, they would indicate a somewhat lower Kimeridgian horizon than is shown in the boulders of north-west Jutland.

"Speaking generally, it may be said that the forms contained in the boulders are such as belong to the middle-European Jurassic province of Neumayr; and in the map accompanying his paper this Scaggerrack region is included in the north temperate zone of Jurassic times, as distinct from the boreal. The beds were laid down under rather similar but more uniform conditions than those of Boulogne, and indicate possibly an eastward continuation

of the same shore-line." Somewhat similar conclusions are drawn from the examination of two Neocomian boulders.

In the second part the palæontology of the fossils found in the boulders is worked out with great care and discrimination, and, in fact, occupies the greater portion of the entire work. The formations are dealt with in order from Lias to Gault inclusive. Much pains is bestowed on the synonymy and distribution of each species recorded, whilst the list of the principal works referred to may serve to show the number of authors consulted. There are eight plates of fossils from photographs executed by E. Wilson, of Cambridge. This method is now largely employed on the Continent, and in cases like the present, where the point is identification rather than description, the results may be regarded as decidedly good. It is clear that some of the fossils cannot have been badly preserved. The Gasteropoda are the least satisfactory.

III.—Geological Survey of Canada. G. M. Dawson, C.M.G., LL.D., F.R.S., Director. Annual Report (New Series), vol. ix, Reports A, F, I, L, M, R, S, for 1896. With plates and maps. 8vo. (Ottawa: Dawson, 1898.)

THIS volume comprises 816 pages and contains five maps and twenty plates. It begins, as usual, with a summary report, addressed to the Minister of the Interior, by the Director, Dr. George M. Dawson, C.M.G., F.R.S., dated 1st January, 1897, which sets forth the work done in the year 1896 at the Museum and head-quarters of the Survey in Ottawa, and that accomplished in the field, the latter including zoological and botanical as well as geological work.

Among other matters of greater or less importance relating to the Museum, the Director insists strongly on the advisability of a new Museum being built, which should be safer and more commodious than the present one, which he alleges to be, both by construction and situation, in grave danger of destruction by fire.

Dr. Dawson brings into prominence once more the essential functions of the Geological Survey by remarking that its chief work is "that of providing geological maps and reports of the several parts of the country, such as to be of value to the explorer, the miner, and others," and he adds that "the demand for information of the kind has been greater than ever before." He further states that the Geological Survey is the only organization under the Dominion Government which undertakes a general mapping of the country as a whole, work which has been carried on from the commencement of the Survey in 1843.

Very notable progress was made during the year 1896 "in the development of the mineral resources of Canada, both in the way of actual work and in attracting the attention and interest of capital. British Columbia has begun to evidence its value as a permanent producer of the precious metals, in a manner long foreseen by those

who have paid attention to its geological structure and position. In Ontario, wherever the Huronian system is developed and has been examined, valuable mines, more particularly those of gold, are being discovered and opened up. In Nova Scotia renewed interest has been shown in gold-mining, and with improved machinery and methods the output is likely soon to be greatly increased. Other mineral industries throughout the country, whether already established or in course of development, share in a general appreciation."

After a short account of the explorations of the field corps, there follow some details of the work done in the Museum, in the sections devoted to chemistry and mineralogy by Dr. Hoffmann, to lithology by Mr. W. F. Ferrier, to mining and mineral statistics by Mr. E. D. Ingall, and to palæontology and zoology by Mr. J. F. Whiteaves, Dr. H. M. Ami, and Mr. L. M. Lambe. Under the last head Mr. Whiteaves' valuable contributions to Canadian palæontology are included, especially the well-known "Palæozoic Fossils." Dr. Ami applies his extensive knowledge of the fossils of the Palæozoic rocks of Canada to aid in the elucidation of stratigraphical problems relating to the geology of Ontario, Quebec, and the Maritime Provinces, and in the preparation of systematic lists of fossils to accompany field reports. Mr. Lambe takes up the study of the Canadian fossil corals, the results of which will be looked forward to with interest by specialists in this difficult group.

The first field report is that of Mr. J. Burr Tyrrell "On the Doobaunt, Kazan, and Ferguson Rivers, and the North-West Coast of Hudson Bay, to Lake Winnipeg." The region explored (in 1893 and 1894) is embraced in an area of about 200,000 square miles, and lies north of the 59th parallel of latitude, and west of Hudson Bay. The report is accompanied by a coloured map on a scale of 25 miles to 1 inch, and by a number of illustrations, reproduced from photographs, which give a very fair impression of the character of the scenery. Many observations on the natural history of the region are interspersed in these pages which are very interesting reading. Of such is the description given by the author of the immense herds of the barren-ground Caribou (*Rangifer Grœnlandicus*) met with on the shores of Carey Lake, an expansion of the Doobaunt River about 40 miles south-west of Doobaunt Lake. Thousands of these animals were collected together in single herds where the explorers had pitched their tents. "The little fauns were running about everywhere, often coming up to within a yard or two of us, uttering their sharp grunts as they stood and looked up at us, or as they turned and ran back to the does. . . . Later in the afternoon a herd of bucks trotted up to us, and stood at about forty yards distance. This was a most beautiful sight, for their horns are now [30th July] full-grown, though still soft at the tips; but unfortunately we had not the camera with us. We did not shoot any to-day." But this is not the story of the hills, and so perhaps thought our explorer, for he returns in the next paragraph to his geological notes.

The two explorations occupied together 15 months, and included the determination of the geographical features of the vast wilderness

travelled over, as well as the character of the rocks and minerals underlying it.

These rocks consist of the following systems:—(1) The Laurentian, which is here "applied almost exclusively to the crystalline, massive or altered, crushed and contorted rocks of the Fundamental Gneiss or 'Basement Complex,' consisting of granites and diorites, and granite- and diorite-gneisses, which it has been impossible to separate in any definite time-series." (2) The Huronian is represented by the Marble Island (Hudson Bay) white quartzite, which Mr. Tyrrell regards as not improbably the oldest part of the Huronian in the region near the north-western shore of Hudson Bay from Marble Island northward to Dawson Inlet southward. This quartzite has associated with it diabase and other basic eruptives, which have been intruded beneath it and have also flowed over it. (3) The Cambrian rocks consist of the Athabasca sandstones and conglomerates occupying the northern part of the region explored. The rock varies from a coarse conglomerate to a fine-grained, red, mottled sandstone, and as no fossils were found in it the age of the formation was determined on stratigraphical and lithological grounds alone. Mr. Tyrrell concludes, however, that as they "hold a position unconformably above the Huronian and below the Cambro-Silurian, they may be assigned with probability to the Cambrian." (4) Two small outliers were the only representatives of the Cambro-Silurian (Ordovician) found within the area surveyed, the one being on an island in Nicholson Lake, the other near Fort Churchill. The fossil contents of these rocks showed them to be of the age of the Trenton Limestone. (5) Silurian rocks were not seen *in sitû*, but masses of white limestone scattered along the river-bank near Churchill are referred to that system on the strength of their fossils, one of which, a *Leperditia*, had been submitted to Professor T. Rupert Jones. (6) The Pleistocene period is here indicated by a great glacier (a map of which is given) called by Mr. Tyrrell the Keewatin Glacier, the most northern of three great centres of glaciation—the Cordilleran, the Keewatin, and the Labradorean, constituting a great névé or 'gathering-ground,' from which the ice flowed outward in all directions.

A description of the till, moraines, eskers, ancient beaches, etc., concludes the geological part of this report, to which three appendices are attached, one on Chippewyan names of places, another a vocabulary of words used by the tribe of inland Eskimos inhabiting the banks of Kazan and Ferguson rivers, and the third containing a list of the plants collected.

Mr. Tyrrell's report is followed by a short one by Dr. Bell on the geology of the French River-sheet of the Survey Map, representing the country at the northern end of Georgian Bay (Lake Huron). The object of this report is to condense the information obtained from various reports by the writer and others, the coloured map accompanying it (on a scale of 4 miles to 1 inch) indicating the geological facts, which are therefore sparingly dealt with in the text. If a vertical section could be made from the mainland along

the western part of the area surveyed and produced southward through La Cloche Island and the eastern end of Grand Manitoulin Island, it would exhibit the following ascending succession :—

	Feet.
Chocolate marls and fine sandstones (Chazy ?) ...	100
Trenton group	320
Utica formation	60
Hudson River formation	250
Clinton formation	177
Niagara formation	405
Guelph formation (?)	100
	1,412

The Laurentian rocks met with consisted of mica- and hornblende-gneisses in even and regular beds, together with coarse hornblende- and mica-schists and bands of quartz-rock with schistose partings. These dip usually at angles of medium inclination.

The most conspicuous feature of the Huronian system is a whitish quartzite which forms great ridges extending eastward from a point on the mainland north-west of Georgian Bay, and again in a south-westerly direction to Lake Huron. Between these two arms of the quartzite, and northward, the most abundant rock is greywacke, which is associated with varying quantities of quartzites, quartz-conglomerates, agglomerates, breccias, sericite- and mica-schists, impure dolomites, and eruptive greenstones. The whole series, including the quartzites, dips at high angles.

The economic minerals in this region include iron, copper, and nickel, but they are not in sufficient quantity to encourage mining operations.

Mr. A. P. Low's report is based upon a traverse of the northern part of the Labrador Peninsula, from Richmond Gulf (Hudson Bay) to Ungava Bay (Hudson Strait). The route taken lay through Clear Water and Seal Lakes and the Stillwater, Larch, and Koksoak Rivers, the last-named emptying into Ungava Bay. The text is illustrated by remarkably good reproductions from photographs, from which a vivid idea is formed of the essentially barren nature of this northern wilderness.

Some general examination into the geology of the country was obtained as time and opportunity permitted, the object being to supplement the results of the explorations of 1892, 1893, 1894, and 1895 in this region embodied in the Report on the Labrador Peninsula.

Laurentian rocks were met with along the greater part of the route. They consisted chiefly of more or less foliated granite, and of eruptive masses of dark-greenish basic granite and diabase. The contact between the Laurentian granite and the stratified and unaltered rocks of the Cambrian is concealed by the deep clays of the valley of Junction River, where the western wall of the valley is formed of granite, while the east side is composed of cherty dolomite and arenaceous shale. Certain schists and gneisses are also classed as Cambrian, of which they represent a highly

metamorphic phase, and to these are added newer intrusions of granite, which have changed the sedimentary Cambrian rocks into schists and gneisses by the heat and pressure due to the intrusion. The unaltered Cambrian rocks, represented by dolomites, shales, and dolomitic sandstones resting unconformably upon Laurentian gneisses, occur on the east coast of Hudson Bay, where at Richmond Gulf they have a breadth of twenty miles. They are traceable also up the Larch River for thirty miles from its junction with the Kaniapiskau. Detailed sections showing the character of the rocks were measured at various places, and these are inserted in the Report, which concludes with a record of the superficial deposits and glaciation of the region traversed.

Dr. L. W. Bailey's report, which is accompanied by a coloured map drawn on a scale of eight miles to one inch, treats of the geology of South-West Nova Scotia, embracing the counties of Queen's, Shelburne, Yarmouth, Digby, and part of Annapolis. This area comprises 3,370 square miles, in which the following groups of rocks are represented :—

1. Granite.
2. Quartzites and slates resembling those of Halifax and Lunenburg Counties, like them auriferous, and believed to be of Cambrian age, but without ascertained fossils.
3. Micaceous, hornblendic, and staurolitic strata, supposed to be the metamorphic equivalents of the Cambrian rocks.
4. Fossiliferous slates and iron-ores of Oriskany or Eo-Devonian age.
5. Red sandstones of Post-Carboniferous age—Triassic ?
6. Trap (dolerite, amygdaloid, etc.), associated with No. 5.

The physical features and surface deposits of the region surveyed are next described; its irregular coastline, with long and narrow inlets, whose resemblance to the fiords of Norway was pointed out by Sir Charles Lyell on his first visit to America in 1841 ; the dunes or sand-hills, moraines, boulders (often of large size), rivers and lakes, kames, and peat bogs ; and the glaciation, very strongly marked in the rocks upon the coast, forming in some places deep, trough-like hollows.

The underlying rocks, largely consisting of those provisionally referred to the Cambrian, exhibit evidence of profound metamorphism in some parts of the area, while in others they are but little altered ; these two conditions passing into each other by insensible gradations. They are separated by Dr. Bailey into three divisions : I, the Quartzite Division ; II, the Banded Argillite Division, consisting of grey and purple slates; and III, the Black Slate Division. These rocks have been affected by the earth movements which have influenced the rock formations along the whole eastern coast of America, and present a series of domes or ridges, usually anticlinal in structure, around which are enwrapped the remains of the higher and less resisting slaty beds. The total area covered by the Cambrian rocks in the district examined is computed at 1,000 square miles.

Siluro-Devonian beds occur in small patches in Annapolis and Digby Counties. It is concluded from the fossils derived from these

deposits, determined or re-examined by Dr. H. M. Ami, "that the beds hold forms referable, some to a transitional series, and others to a horizon at the base of the Devonian [Eo-Devonian of H. S. Williams]," and this is "in accordance with the stratigraphy of the district, which indicates a perfectly continuous and conformable series of beds."

Red sediments, assigned with a query to the Triassic epoch, underlie the Annapolis Valley, and traps occurring in the long but interrupted ridge forming the North Mountain of Annapolis County, Digby Neck, Long and Briar Islands, are regarded as possibly of contemporaneous origin.

Among the economic minerals of this part of Nova Scotia gold occupies an important place. The results of mining the precious metal, though apparently somewhat checkered, seem to have been on the whole of an encouraging nature, and there are some properties yielding good returns and promising still better. A detailed account of the gold-mining industry is given by Dr. Bailey in his report, and he also refers to the ores of iron found and worked in the area under review. Excellent 'process' illustrations enrich this report similar to those of the other reports in this volume.

Dr. G. Christian Hoffmann's report of the section of Chemistry and Mineralogy contains a record of the more interesting results obtained by the examination and analysis of various rocks and minerals submitted to him, in which his assistants, Messrs. Waite and Johnston, bore their share.

In the section of Mineral Statistics and Mines (Annual Report for 1896) Mr. E. D. Ingall, assisted by Messrs. Cole and McLeish, makes an important contribution to this subject, so vital to the interests of a country possessing the mineral wealth of Canada. A few words from the introduction to this report will suffice to show what rapid strides the country is making in mineral development. "In 1886 the total mineral production of the country, as per direct returns, supplemented by close estimates where complete returns could not be obtained, was valued at a little over ten million dollars. In 1896 the value of Canada's mineral production had increased 125 per cent. or to over twenty-two and a half million dollars."

The Report closes, as usual, with a good Index.

ARTHUR H. FOORD.

REPORTS AND PROCEEDINGS.

February 17, 1899.—W. Whitaker, B.A., F.R.S., President, in the Chair.

ANNUAL GENERAL MEETING.

The Secretary read the Reports of the Council and of the Library and Museum Committee for the year 1898. In the former the Council congratulated the Fellows on their increase in numbers and on the continued financial prosperity of the Society.

During 1898 the number of Fellows elected was 52: of these 41 qualified before the end of the year, making with 17 previously elected Fellows, a total accession of 58 in the course of the twelvemonth. During the same period, the losses by death, resignation, and removal amounted to 52, the actual increase in the number of Fellows being 6.

The total number of Fellows, Foreign Members, and Foreign Correspondents, which on December 31st, 1897, was 1,333, stood at 1,339 by the end of 1898.

The balance-sheet for the year 1898 showed receipts to the amount of £3,575 7*s.* 1*d.* (including a balance of £723 3*s.* 0*d.* brought forward from the previous year), and an expenditure of £2,499 6*s.* 5*d.*, the balance remaining available for the current year being £1,076 0*s.* 8*d.*

The Secretary of H.M. Office of Works having announced that the Department proposed to lay down a new system of drainage in connection with the Society's apartments, the Council had pointed out the need for improved lavatory accommodation. This the Office of Works consented to provide, on condition that the Society shall contribute the sum of £200 towards the cost thereof—a proposal which the Council advised the Fellows to accept.

It was announced that the MS. of the Third Volume of Hutton's "Theory of the Earth," edited by Sir Archibald Geikie, is now in the press, and that it is proposed to print a number not exceeding 500 copies.

The completion of vol. liv and the commencement of vol. lv of the Society's Quarterly Journal was mentioned, and attention was called to the fact that in this and future years the Record of Geological Literature added to the Society's Library will be issued concurrently with the May number of the Journal. Reference was also made to the issue of Index Slips with each number.

The new system adopted during the past year with regard to the selection of papers for publication in the Quarterly Journal was explained, and the awards of the various medals and proceeds of donation funds in the gift of the Council were announced.

The report of the Library and Museum Committee enumerated the large additions made to the Society's Library during the past year, and announced the approaching completion by Mr. C. Davies Sherborn of the work of labelling and registering the type- and other interesting specimens in the Museum.

The reports having been adopted, the President presented the Wollaston Medal to Professor Charles Lapworth, LL.D., F.R.S., addressing him as follows:—Professor Lapworth,—

On four occasions has the Council of this Society already delighted to do you honour, with the Murchison Fund in 1878, with the Lyell Fund in 1882 and 1884, and with the Bigsby Medal in 1887. Our Funds are usually awarded with the desire of helping observers and of stimulating them to further efforts, and from this point of view the Funds awarded to you have certainly been most profitable investments. Nor could the Bigsby Medal, with its age-limit, have been better bestowed than on one who had done so much and such good work before reaching the age of 45.

At that time, however, the effect of your work could hardly be appreciated to the full. I believe that the appreciation of it will increase as time goes on, and I am glad to know that in an elaborate Memoir on the Silurian Rocks of Scotland, shortly to be published, the Officers of the Geological Survey do full justice to your series of papers on those rocks in the South of Scotland, saying that you have furnished a complete solution of the stratigraphical and palæontological difficulties of the subject, and have discovered the key to the complicated stratigraphy of the region. The summary, at the end of the chapter on Previous Researches, is written "to place clearly on record the distinctive features of Professor Lapworth's achievements, ... which resulted in establishing the true order of succession of the strata."

We hardly know, indeed, which to admire most, the brilliance of your work or the single-mindedness with which it has been done; not only in the Scottish Uplands, but also in the still more remarkable region of the North-Western Highlands, where the officers of the Geological Survey have now worked out in detail that most complicated structure which you so justly appreciated.

In establishing the Ordovician System, too, you have done your best to promote harmony between the rival claimants for Cambrian and for Silurian.

Since the Bigsby Medal was awarded to you your labours in various branches of Geology have been continued, notably in further working out the structure of the Southern Uplands of Scotland, in the discovery of the English *Olenellus*-rocks, and in additions to our knowledge of the *Olenellus*-fauna and its geological relations. Your researches on the ancient rocks of Shropshire have been published only in abstract; the striking results at which you have arrived lead us to hope that ere long they may be published in full.

In your address to the Geological Section of the British Association in 1892, you astounded your hearers by the way in which you applied your knowledge of mountain-structure to questions of the largest kind, showing a breadth of view that had not been surpassed by any geologist.

Lately, and in quite another line of work, in that admirable Sketch of the Geology of the Birmingham District, issued by the Geologists' Association last year, you have given us one of the best accounts of any English district that we possess, weaving in the work of others and giving it the character of a perfect fabric.

It is not only, however, for your work as a geologist that we wish to honour you, but also for your work as a teacher. In saying this, I do not refer merely to your professional work, excellent though it be, but rather to that highest of all teaching, the influence that you have had on your fellow-workers in Geology. That influence is to be traced in much of the best work that we have had of late years, and during our present Session we have had important papers which, I venture to say, would not have been written but for lines of thought suggested by you. We look forward to a long continuance of your brilliant labours.

Professor Lapworth replied in the following words:—Mr. President,—

I am deeply grateful to the Council of the Geological Society for the great honour which they have conferred upon me by the award of the Wollaston Medal; and to you, Sir, for the kindly, and indeed too kindly, terms in which you have referred to my scientific work.

It was my happy lot to have, at the very outset of my geological career, the aid and encouragement of a master in the science—my dear friend, the late Professor Alleyne Nicholson. It has been my good fortune to live in districts where some new geological work could be done. And more, since the day when I read my first geological paper, I have been encouraged and stimulated by the friendship and the sympathy of many earnest geologists.

When I think of my many opportunities, and remember how often my results have fallen sadly short of my aims, I feel that this distinction is less a reward than a consolation. But I accept it as an outward and visible sign that the Council are well aware that the same instinctive love for our glorious and all-embracing science as that which inspired those whose names adorn the illustrious roll of the past Wollaston Medallists, has also prompted and guided me in my work, and has given me a place in the generous regard of the Fellows of the Geological Society.

In handing the balance of the proceeds of the Wollaston Donation Fund (awarded to Prof. J. B. Harrison, M.A., F.G.S.) to Mr. J. J. H.

Teall, M.A., F.R.S., for transmission to the recipient, the President addressed him as follows:—Mr. Teall,—

I have the pleasure of handing over to you the balance of the Wollaston Fund for Professor J. B. Harrison, in acknowledgment of his work in the West Indies and British Guiana. In the course of the last eight years he has contributed several papers to the Society (in conjunction with Mr. Jukes-Browne and Mr. G. F. Franks) on the Geology of Barbados, which have added much to our knowledge of old coral-reefs, of the past physical geography of the region in which they occur, and of the oceanic deposits with which they are associated. In this work, his ability as a chemist has been of great service.

He has also done most of the field-work for the Geological Map of Barbados, and has visited other West Indian Islands and part of British Guiana, in order to draw up official reports on soils and gold-bearing rocks. In the last of these visits, made last year, he suffered repeated and nearly fatal attacks of fever, from which he was slowly recovering in December, when we last heard from him.

Mr. Teall replied in the following words:—Mr. President,—

In handing this award to me for transmission to Professor Harrison, you place me in a somewhat unusual position. No communication has been received from Professor Harrison since the award was decided upon by the Council. All that we know about him is that, in December last, he was recovering from an illness brought on by work in the interior of British Guiana, and was contemplating a journey to Barbados in January. The fact of our not having received any acknowledgment from him is, therefore, probably due to his absence from Georgetown.

I need not repeat what you, Sir, have said about his scientific work in the West Indies and British Guiana. He is a man who, in the midst of professional engagements, and without the stimulus of frequent, sympathetic intercourse with fellow-workers in science, has yet found time to carry out important scientific researches in far-distant British Colonies. I feel sure that he would wish me to express, on his behalf, the deep sense of the honour which has been conferred upon him, and to assure the Society that this mark of their appreciation will encourage him to continue his scientific work.

The President then presented the Murchison Medal to Mr. B. N. Peach, F.R.S., and a second Murchison Medal to Mr. J. Horne, F.R.S.E., addressing them as follows:—Mr. Peach and Mr. Horne,—

Since the years 1887 and 1888, in which the Wollaston Fund was awarded to you successively, you have continued your work in Scottish Geology, taking a leading part in the latter year in that Report on the Recent Work of the Geological Survey in the North-Western Highlands, printed in our Journal, in which the new view of the structure of that region is described in some detail. You have also dealt with the *Olenellus*-zone in the same district, and, ascending greatly in the geological scale, you have discussed Glacial geology and have undertaken Cavern-research.

Mr. Peach, moreover, has done much palæontological work, having long acted as Palæontologist to the Scottish Survey, and it should not be forgotten that he described the first fossil scorpion found in the Silurian rocks of Scotland. He has also given us a paper on some additions to the fauna of the *Olenellus*-zone, and has noticed a radiolarian chert of Arenig age.

Mr. Horne, either alone or in conjunction with other colleagues, has given us a paper on "Foliated Granites and their Relations to the Crystalline Schists," showing an intimate relation between the two rocks and that the foliation in the former may have originated in at least two ways; he has communicated other papers to the Geological Society of Edinburgh, on igneous rocks, on volcanic necks, on fossiliferous Cambrian and Carboniferous rocks, and on glaciation, taking part also in the Report of the British Association Committee on the Shelly Clays of Clava and Kintyre, and in the work of the Inverness Society.

Your association together has been productive of much good work, and we hope that it may long continue. In handing the Proceeds of the Wollaston Fund to one of you in 1888, Professor Judd remarked that as in your researches you had been so constantly united, in the recognition of your services you should not be divided, and that the name of Horne would appropriately follow that of Peach. On the present

occasion, I am glad to say that we have allowed no interval between the names, but have, still more appropriately, I think, than before, coupled them together by awarding a Medal to each of you. This award seems to me to go very naturally with that of the Wollaston Medal to Professor Lapworth, as you have both so largely helped in the detailed working-out of subjects that he brought before you.

Mr. Peach, in reply, said:—Mr. President,—

The honour which the Council of the Geological Society have conferred upon me is highly prized by me, because it was by the advice of Sir Roderick Murchison that my thoughts were turned to Geology as a career in life. By means of his generosity I was able to avail myself of the scientific training afforded by the Royal School of Mines, and through his nomination I received an appointment on the Geological Survey.

I ask you, Mr. President, to convey my heartfelt thanks to the Council for having awarded me the Murchison Medal which, for me, has such tender associations. If anything could enhance the pleasure of this Award, it is the receiving it from the hands of one colleague and the sharing of it with another.

Mr. Horne also replied, as follows:—Mr. President,—

It is a source of great gratification to me that I have been deemed worthy by the Council of this Society to receive the Murchison Medal jointly with my old friend and colleague, Mr. Peach. For he gave me my early training in field-work, and to his range of knowledge and ample experience I have owed much during my Survey career.

It is likewise a special pleasure to be linked with the great founder of this Medal, whose name is so closely associated with the history of Scottish Geology. While preserving a feeling of loyalty to our former chief and his successors in office, we have at the same time tried to exercise independence of judgment in dealing with Scottish geological questions. In doing so, we have realized, perhaps more vividly than others, the permanent value and brilliant power of Professor Lapworth's researches in Scotland, whose reception at this anniversary of the highest honour which the Council can bestow is a great pleasure to us. Regarding the Geology of the North-Western Highlands, we feel that our colleagues who have worked with us in that complicated region justly share in the honour which has been conferred upon us.

In handing the balance of the proceeds of the Murchison Geological Fund (awarded to Mr. James Bennie, of the Geological Survey of Scotland) to Sir Archibald Geikie, D.Sc., F.R.S., for transmission to the recipient, the President addressed him in the following words:—Sir Archibald Geikie,—

In handing over to you the balance of the proceeds of the Murchison Fund for Mr. Bennie, I have the pleasure of doing honour to one who has supplemented his work for the Geological Survey by other labours.

He began geological observations in 1850, while employed in a Glasgow warehouse, by collecting fossils from the Lower Carboniferous rocks of the neighbourhood, and he also examined the Glacial deposits, communicating his results to the Geological Society of Glasgow.

He joined the Survey, as fossil-collector, in 1868, and held that post until lately, when he had to retire on account of age.

In 1873 he first discovered Holothuridæ in Scottish Carboniferous rocks. He found new species of Blastoidea (described by Mr. R. Etheridge, jun., and Mr. Carpenter) and also Brachiopoda adhering to crinoid-stems (producing pathological modifications of the latter). He assisted the late H. B. Brady with specimens of Carboniferous Foraminifera, for his Monograph; wrote a paper, jointly with Mr. Kidston, for the Royal Physical Society of Edinburgh, "On the Occurrence of Spores in the Carboniferous Formation of Scotland"; and, more lately, worked with great success in the collection of Arctic plants from deposits of Glacial age.

We hope that he may still be able to continue his useful labours.

Sir Archibald Geikie replied as follows:—Mr. President,—

Mr. Bennie has commissioned me, on his behalf, to receive this award, and to express to the Council and the Society his grateful thanks for the honour that they

have conferred upon him. His long life has been enthusiastically devoted to geological pursuits. Before he joined the Geological Survey, the scanty intervals of leisure which he could snatch from the daily toil of his avocation were given up to the search for fossils among the Carboniferous and Pleistocene deposits around Glasgow. When he became Fossil-Collector to the Survey he was enabled to pursue as his regular and ordinary employment what had before been the occupation of his brief hours of recreation. And now, having passed the age-limit of the Civil Service, and having retired on a small pension, he continues to work on in his old way, and appears daily still in his accustomed place in the Survey Office, busy with the search for micro-organisms among the silt and peat which he gathers from some of the floors of vanished Arctic lakes around Edinburgh. The stores of knowledge which he has slowly amassed have always been at the disposal of others who could make good use of them. That his quiet, unobtrusive labours should have attracted the notice and received the approbation of the Geological Society has been to him a source of deep gratification. As long as life and strength remain, he will continue the work which has been the chief pleasure and solace of his career.

The President then presented the Lyell Medal to Lieut.-Gen. C. A. McMahon, F.R.S., addressing him as follows:—General McMahon,—

Besides your petrological work in India you succeeded, by work in the field as well as with the microscope, in tracing out the relations of the gneissose granite or central gneiss of the Western Himalayas, and in proving its intrusive character as well as its Tertiary age. You thereby threw much light on the theory of the origin of that great range, to a knowledge of the Glacial geology of which you have also contributed.

Returning to this country, you have given our Society several papers, chiefly on the rocks of Cornwall and of Devon. In these you have contended that the serpentine of the Lizard district is intrusive, that the banded structure of the accompanying gabbros is due to fluxional movements, and that the granite of Dartmoor is an intrusive igneous rock of the usual character. These papers and various communications to the GEOLOGICAL MAGAZINE show that, besides being a skilled observer, you have the valuable adjunct of critical ability, combined, I need hardly say, with all courtesy. Kindred Societies, too, have had the benefit of your work, in the microchemical examination of minerals among other things. Nor has your Indian experience remained unused.

Labouring under the disadvantage of taking to the study of Geology comparatively late in life, you have attacked it with the energy of a British soldier, and have fought your way into the foremost ranks of our petrologists.

Lieut.-Gen. McMahon, in reply, said:—Mr. President,—

I feel deeply the honour conferred upon me by the Council of the Geological Society in awarding to me the Lyell Medal, as a recognition of my humble efforts to advance the cause of Geological Science. The pleasure which this has given me is greatly enhanced by the kind and flattering way in which you have spoken of my work, and by the sympathy accorded to me on this occasion by the Fellows of the Society.

It is very gratifying for an amateur to have his work stamped with the hall-mark by specialists who have made Geology the study of their lives. I have always received help and encouragement from professional geologists, and had it not been for the generous aid which they have invariably been ready to afford, I should not this day have been a recipient of the Lyell Medal.

In handing to Mr. Frederick Chapman, A.L.S., F.R.M.S., a moiety of the balance of the proceeds of the Lyell Geological Fund, the President addressed him in the following words:—Mr. Chapman,—

You have been an enthusiastic worker with the microscope for many years, and half of the balance of the Lyell Fund has been awarded to you as a mark of our regard for what you have done for the fossil Foraminifera and other Microzoa, much of your work being published by the Royal Microscopical Society.

Your earlier papers, written in conjunction with Mr. Sherborn, were based on the London Clay of our immediate neighbourhood, and then on that of Sheppey.

You have also dealt with the Foraminifera of the Gault, writing a set of ten papers specially on the Gault of Folkestone (1891–98). The microscopic fauna of the Phosphatic Chalk, of the marl and silts of Barry Docks, and of Barbados deposits have been described by you in our Journal, and you have also given us an elaborate paper on the Bargate Beds and their Microscopic Contents (1894). Rhætic Foraminifera you have described in the Annals and Magazine of Natural History, Pleistocene Ostracoda and Jurassic Microzoa in the Proceedings of the Geologists' Association, nor have you neglected recent Foraminifera.

That you should have so well used the opportunities which you have had while serving under Professor Judd is a source of satisfaction to us, and we hope that this award may be an encouragement to you in further researches.

Mr. Chapman, in reply, said:—Mr. President,—

I desire to express my sincere thanks to the Council of this Society for selecting me as one of the recipients of the Lyell Award, and to you, Sir, for the very encouraging words with which you have honoured me. However little my work in the past may have merited this distinction, I trust that, with further opportunities, my later endeavours in Micropalæontology and other branches of microscopical work will in some degree justify this selection. I cannot let this occasion pass, without saying how much direct help and advantage I have derived from the methods of geological research carried out in Professor Judd's laboratory at the Royal College of Science. Nor would I forget the invaluable advantages which I have derived from the friendship of those engaged in the same line of research, and especially are my obligations due to Professor T. Rupert Jones and Mr. C. Davies Sherborn.

The President then handed the other moiety of the balance of the proceeds of the Lyell Geological Fund to Mr. John Ward, F.G.S., addressing him as follows:—Mr. Ward,—

One-half of the Balance of the Lyell Fund has been awarded to you, in recognition of your long services to the Geology of your district. You have devoted many years to the study of the Geology of North Staffordshire, making a large collection of fossils, especially Vertebrata, from the Coal-measures, including many new forms, and thus aiding, with material, the researches of various palæontologists, including Egerton, Huxley, and Traquair.

For nearly 40 years you have contributed valuable papers to local societies and to mining institutes, among which is a detailed essay on the Geological Features of the North Staffordshire Coalfield and the record of a rich marine fauna in certain horizons of Coal-measures. Your detailed and accurate knowledge of the district has always been freely placed at the service of other observers.

Mr. Ward, in reply, said:—Mr. President,—

It is difficult for me adequately to express my appreciation of the high honour conferred by the Council of the Geological Society in awarding to me a moiety of the balance of the Lyell Fund; and to yourself, Sir, my best thanks are due for the complimentary terms with which you have supplemented it.

Forty years and upwards have now passed away since I was first led by the inspiring influence of an old and much revered friend, the late Dr. Garner, author of the "Natural History of the County of Stafford," to devote my leisure hours to the investigation of the fossil fauna and flora of the North Staffordshire Coalfield.

It has been my good fortune to labour in a field which, although local, is one that affords abundant facilities for research in Carboniferous Palæontology, and to have been led to the investigation of a branch of our science which had previously been greatly neglected. My attention has principally been directed to one special line of research—the fossil Vertebrata, of which class I have collected between 3,000 and 4,000 specimens of fossil fishes and reptilian remains. Of the former, about 40 genera and species are new to science, in addition to many rare and unique examples. Within the past few years, the principal portion of my collection has been added to the National Collections in Cromwell Road, whilst another portion enriches the geological collection in the Edinburgh Museum.

I avail myself of the present opportunity to acknowledge my gratitude to the many eminent palæontologists to whose generous assistance and encouragement I owe so much of my success. To Dr. Traquair my thanks are specially due for the valuable

assistance and friendly aid accorded to me during the past eighteen to twenty years. Not only has he assisted in naming specimens, but he has contributed to science a number of papers and separate monographs devoted to the elucidation of the structure and affinities of new and rare genera and species of fossil fishes from my collection.

I shall look upon the award not only as bearing the stamp of approval and generous recognition of the Council of the Society for my past services to Palæontological Science, but also as an additional incentive to me to continue with renewed energy those researches the pursuit of which has been to me a labour of love for so many years. It will be not only my aim, but my highest ambition, in the time that yet remains to me, to contribute to our common science results that will be of greater scientific value than anything I have hitherto been able to offer, and to render myself more worthy of the distinction which has been conferred upon me.

The President in handing the Bigsby Medal (awarded to Professor T. W. Edgeworth David, B.A., F.G.S.) to Professor J. W. Judd, C.B., LL.D., F.R.S., for transmission to the recipient, addressed him in the following words:—Professor Judd,—

As, after studying under Sir Joseph Prestwich at Oxford, Professor David had the advantage of attending your courses at the Royal College of Science, it is fitting that you should receive the Bigsby Medal for him.

After having engaged in an investigation of the Glacial phenomena of his native district, South Wales, the results of which were published in our Journal and reprinted by the Cardiff Naturalists' Society, Professor David was appointed to the Geological Survey of New South Wales, and during his nine years' service thereon many reports and maps, as well as independent papers on various branches of our science, show his devotion to his work.

In 1891, having been made Professor of Geology in the University of Sydney, he threw himself with energy into the work of teaching.

Among the series of scientific communications from his pen, two must be specially remembered by many of us, namely, his paper on Evidences of Glacial Action in Australia in Permo-Carboniferous Time, ably delivered by himself in this room in 1896, and generally thought to be the most convincing on the subject, and lately the equally important paper on the Radiolarian Cherts of New South Wales, read, in his absence, by Dr. G. J. Hinde.

Besides so much good work in his own Colony, he has greatly assisted in the investigation of the Coral-atoll at Funafuti, and it is to his energy and perseverance that the success of this undertaking is largely due.

The Council of the Geological Society do not forget our Colonial brethren, but delight to honour those who, like Professor David, do good work in our far-off lands.

Professor Judd, in reply, said:—Mr. President,—

On behalf of my friend, Professor Edgeworth David, I thank you for the kindly terms in which you have spoken of his work. Part of that work is known to all Fellows of this Society, by the papers which Professor David has contributed to our Journal. But another, and very large part, is the record of geological studies carried on during the last twenty years in his adopted country—the great Colony of New South Wales. There is, however, one labour of his, which I believe will prove to be of especial importance in advancing Geological Science. I refer to what he has done in connection with the boring of a Coral-atoll in the Pacific Ocean. Three expeditions in successive years have resulted in the carrying down of the boring at Funafuti to the depth of 1,114 feet. The leader of the first expedition—Professor Sollas—assures me that he owed much to the aid and good-will of Professor David in starting this important enterprise. In the second expedition, Professor David, with his accomplished and energetic wife, went out to Funafuti, and they were largely instrumental in overcoming the serious difficulties of the work. The third expedition, in which the triumph of the investigation was finally assured, would probably never have been set on foot but for his indomitable perseverance, and for the tact and the influence which Professor David brought to bear on all who could aid in this important undertaking. The last portion of the core obtained by the Funafuti boring will probably be in this country within a few days, and, from what I have seen of the other parts

of the core, I am convinced that its study by zoologists, botanists, and chemists will result in new information being obtained concerning the origin of coral-reefs—information which will prove of inestimable value to the geologist.

The President then proceeded to read his Anniversary Address, in which he first gave Obituary Notices of several Foreign Members, Foreign Correspondents, and Fellows deceased since the last Annual Meeting, including W. Dames (elected F.M. in 1895), C. W. von Gümbel (F.M. in 1877), James Hall (F.M. in 1848), J. Marcou (F.M. in 1879), Fr. von Sandberger (F.M. in 1875), A. Briart (F.C. in 1884), W. G. Atherstone (elected a Fellow in 1864), M. Attwood (elected in 1876), D. Bell (elected in 1892), W. Colchester (elected in 1857), Sir J. Fowler (elected in 1845), W. C. Lucy (elected in 1861), H. A. Nicholson (elected in 1867), T. Sopwith (elected in 1872), E. Wilson (elected in 1872), and others.

He then drew attention to various subjects in which Geology has a practical application. Firstly, as regards water-supply, the geology of the gathering-ground is always of importance. In selecting sites for reservoir-dams certain sorts of ground have generally to be avoided, as of unstable character, whether from great disturbances, from the occurrence of irregular masses of Drift, or from landslips. The presence of pervious beds in a reservoir may also lead to trouble. Illustrations of these matters are given by some of the waterworks for Manchester and for Sheffield.

In getting water by means of wells, geological considerations are of great importance in fixing sites. While we can see springs and streams, we have to infer much in dealing with underground water. For large supplies we must go to permeable formations of fair thickness and of broad outcrop, and should select sites where a large area of gathering-ground can be brought under contribution. The flow of water underground has to be studied, and the character of the water-bearing rocks noticed, although there is often much difference in this latter between beds at or near the surface and the same beds at great depths underground.

Waters, too, vary with their depth, those found near the surface often differing greatly in mineral contents from those in the same beds at great depths: as, for instance, the waters of the deep wells in London compared with those of wells in the bare chalk.

In selecting sites for sewage-farms and for cemeteries, Geology is again of importance, and it is especially needful to prevent the contamination of water-bearing formations. A recent research of Dr. Klein is of great interest, as showing the strong filtering-power of fine compact sand in stopping the passage of microbes, whether in water or in the dead bodies of guinea-pigs.

Illustrations of the evil results of neglect in the protection of water-supplies from contamination are given by the outbreak of fevers at Worthing, with a well-supply, and at Maidstone, with a spring-supply.

For the proper consideration of all these questions, it is needful to have, firstly, a map on which the divisions of the Drift are shown; and, secondly, a geological map on a large scale. Reference was made

to the work of the Geological Survey in these and in other practical questions.

The Ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council*: W. T. Blanford, LL.D., F.R.S.; Professor T. G. Bonney, D.Sc., LL.D., F.R.S.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; E. J. Garwood, Esq., M.A.; J. W. Gregory, D.Sc.; Alfred Harker, Esq., M.A.; F. W. Harmer, Esq.; R. S. Herries, Esq., M.A.; Henry Hicks, M.D., F.R.S.; Rev. Edwin Hill, M.A.; G. J. Hinde, Ph.D., F.R.S.; W. H. Hudleston, Esq., M.A., F.R.S., F.L.S.; Professor J. W. Judd, C.B., LL.D., F.R.S.; H. W. Monckton, Esq., F.L.S.; F. W. Rudler, Esq.; Professor H. G. Seeley, F.R.S., F.L.S.; A. C. Seward, Esq., M.A., F.R.S.; Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; A. Strahan, Esq., M.A.; Professor W. W. Watts, M.A.; W. Whitaker, Esq., B.A., F.R.S.; Rev. H. H. Winwood, M.A.; A. S. Woodward, Esq., F.L.S.

Officers.—*President*: W. Whitaker, Esq., B.A., F.R.S. *Vice-Presidents*: Henry Hicks, M.D., F.R.S.; Professor J. W. Judd, C.B., LL.D., F.R.S.; Professor W. J. Sollas, M.A., D.Sc., LL.D., F.R.S.; Rev. H. H. Winwood, M.A. *Secretaries*: R. S. Herries, Esq., M.A.; Professor W. W. Watts, M.A. *Foreign Secretary*: Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer*: W. T. Blanford, LL.D., F.R.S.

CORRESPONDENCE.

EGYPTIAN CRETACEOUS SHELLS.

Sir,—Dr. Blanckenhorn, of the Geological Survey of Egypt, has recently favoured me with some detailed evidence, which goes to prove that a part of the Cretaceous mollusca from Egypt described by me in the Geological Magazine for 1898, p. 394, as having been collected in districts eastwards of the Nile and Nile Valley, are of Campanian age, and not Turonian. This renders it desirable to regard the following species as Campanian: *Ostrea Lyonsi, O. Villei, Protocardia biseriata, Trigonoarca multidentata,* and *Arctica Barroisi.* Dr. Blanckenhorn further calls attention to the Cretaceous rocks of Abu Roasch, which he recognizes as belonging to the two horizons of Turonian and Santonian, and not to the former only, as indicated in my paper. In support of this age I alluded to the discoveries of M. Jules Welsch among similar deposits in Algeria; and without repeating this information I feel justified, in the absence of more important palæontological evidence from this area of Egypt, in considering these beds as Turonian. R. Bullen Newton.

SUB-OCEANIC PHYSICAL FEATURES.

Sir,—I must reply to Professor Hull's very kind letter that I *do* mean, that it may have been in consequence of their original union on two sides of a rent, that the physical features on the opposite sides of the Atlantic possess a remarkable similarity. I wish to inquire of those who are studying the submarine declivities, whether or not this similarity is more marked in them than in the coastlines.

It was expressly for the purpose of eliciting opinions upon this question that I wrote. Professor Hull gives his, that such a rent is impossible. I should imagine that he has not fully considered my

"Speculation on the Origin of Ocean Basins," or he would have given his reasons for saying so. The matter appears to me to turn upon the question, whether there was a hardened crust upon the earth at the time of the genesis of the moon, or whether there was not. If there was, I do not see any impossibility in my explanation of the origin of the oceans; and it agrees with several remarkable facts, such as the greater density of the crust beneath the oceans, and this very point of the apparent rent between the Eastern and Western Hemispheres. It is obvious that, if my speculation is correct, we need go no further to account for the origination of these great declivities.

I would respectfully ask geologists interested in this subject to refer to my article in *Nature*, vol. xxv (1882), p. 243, or to chap. xxv of my "Physics of the Earth's Crust," second edition, that they may see what my speculation really is before rejecting it.

O. Fisher.

Harlton, Cambridge.
March 7, 1899.

THE EASTERN SLOPE OF THE NORTH ATLANTIC BASIN: IS IT A STEEP OR A GRADUAL INCLINE?

[The Editor has received the following note from Rear-Admiral Sir William Wharton, K.C.B., F.R.S., the Hydrographer of the Admiralty; and as it bears directly upon the nature of the so-called 'escarpment' of Professor Hull, referred to by Mr. A. J. Jukes-Browne in his recent letters, and also to Mr. Hudleston's important article, we think it will be perused with great interest by the readers of the Geological Magazine.—Edit.]

Sir,—In reply to your question as to what is known of the steepness of the slope of the eastern margin of the North Atlantic Basin, and whether there are on it any submarine vertical precipices 7,000 feet or so in height, I can only say, in regard to the latter, that while no man could affirm positively that none may exist, it is certain that there is not a shred of evidence in their favour.

In 1862, in the early days of telegraphy, H.M.S. "Porcupine," commanded by Captain Hoskyn, was sent especially to investigate this edge of the deep water west of Ireland, with a view to ascertaining whether the slope was such as would prevent the maintenance of a submarine cable laid on it. He searched the edge for a distance of 180 miles, and perhaps the following sentences from his report may be taken to sum up his results so far as your inquiry is concerned:—

"Much pains were taken, by sounding at short intervals, to discover if anything like a precipice existed. Our steepest incline shows a difference of level of 3,060 feet in 2·7 miles, or about 19 feet in 100 feet. On the parallel of 51° 20′ we have a dip of 7,680 feet in a distance of 14 miles. The intermediate soundings give no evidence of a precipice, but a mountain of this height on the land would present an imposing appearance, with perhaps some steep escarpments."

"On examining the soundings the slope will be found to vary from 6 feet to 19 feet dip in 100 feet horizontal, a dip that cannot possibly injure or strain the cable."

With regard to the remaining portion of the slope to the southward into the Bay of Biscay, it has never been examined with a view of ascertaining the angle. Though in time a great many soundings have been accumulated, as the charts will show, they are the results of many ships, and you will understand that, as a consequence of the uncertainty of finding the precise position of a ship at sea, when the results of two or more ships are compared, there may be considerable errors. But from what we have, the result is the same, i.e. a gentle slope varying from 2° to 10° from the horizontal.

I send you some slopes drawn from what information we possess, which include the edge of the deep water from 46° N. lat. to 54° N. lat., and which speak for themselves. You will see that the angles are as I say. I may further mention that I know of no steep submarine precipices in the oceans in any part of the world, except those round coral islands, and perhaps in a few cases round the edges of submerged banks, doubtless of volcanic origin.

W. J. L. Wharton.

OBITUARY.

WILHELM BARNIM DAMES.

Born June 9, 1843. Died December 22, 1898.

By the death of Professor Dames, Germany loses one of its foremost palæontologists, and the University of Berlin one of its most distinguished Professors. Born at Stolp, in Pomerania, in 1843, he studied at Breslau under Ferdinand Roemer, and also at Berlin under Beyrich. He graduated at Breslau in 1868, his thesis on the Devonian rocks of Freiburg, Lower Silesia, being published by the German Geological Society in the same year. The troublous times of the Franco-German War then interrupted his researches, and in September, 1870, he was wounded near Chevilly. After recovery he went to Berlin, in 1871, as assistant in the Geological Museum of the University, and became Custos in 1875. He was appointed Professor Extraordinarius in the University in 1878, and was promoted to an ordinary professorship, on the death of Beyrich, in 1891. He was elected a member of the Prussian Academy of Sciences in 1892.

During the first decade of his scientific researches Professor Dames was occupied chiefly with fossil Invertebrata, and his most important contribution was his description of the Echinoidea of the Jurassic of N.W. Germany, published by the German Geological Society in 1872. In 1881 he began to take special interest in the Vertebrata, publishing a small note on some Selachian teeth (*Rhombodus Binckhorsti*) from the Maastricht Chalk. At this time he was entrusted with a memoir on the famous second specimen of *Archæopteryx*, which was published, in 1884, in vol. ii of the "Palæontologische Abhandlungen"—a valuable serial founded by

Professors Dames and Kayser, on the plan of the older "Palæontographica," in 1883. The memoir on *Archæopteryx*, with its brief supplement in 1897 (Sitzb. k. preuss. Akad. Wiss.), will remain one of the classics of Palæontology. After a visit to Greece, Professor Dames described some remains of *Hyænarctos*, *Cervus*, and a rodent from Pikermi (1883); while in 1888 he returned temporarily to the study of Invertebrata, publishing a paper on Crustacea from the Cretaceous of Mount Lebanon. The most important memoirs of his later years were those on the Ganoid Fishes of the Muschelkalk (1889), on Chelonia from the North German Tertiaries (1894), on Zeuglodont remains from Egypt (1894), and on *Plesiosaurus* from the Lias of Southern Germany (1895). Of these, the first three were published in the "Palæontologische Abhandlungen," while the fourth was a memoir of the Prussian Academy. At the time of his death the Professor had in preparation a description of the Neocomian fishes of Hildesheim, Hanover, and a paper on *Stereosternum* from Brazil. From 1885 onwards he had been joint-editor of the "Neues Jahrbuch für Mineralogie."

Professor Dames travelled extensively in Europe and was well known in this country, where he was honoured by election as Foreign Correspondent to the Geological Society of London in 1891, and as Foreign Member of the same Society in 1895. He married a Russian lady, Baroness Mathilde von Toll, of Kuckers, in Esthonia. His last journey was one in the vain search of health, through Norway, during the summer vacation of 1898.

We have just received the mournful intelligence of the death, from pneumonia, of our valued friend of 33 years, Professor O. C. Marsh, of Yale University, New Haven, Conn., on the 18th March, in his 68th year. Few men of this century have done more to advance vertebrate palæontology than Professor Marsh, or have left behind larger contributions to the science.—H. W.

MISCELLANEOUS.

The Museum of Practical Geology, Jermyn Street.—It has been decided by the Government not to remove the Museum of Practical Geology from Jermyn Street to South Kensington. Opinions have differed with regard to the desirability of this course. On purely scientific grounds it would have been well to have the Geological Survey collection of fossils, which are stratigraphically arranged, alongside of the British Museum fossils, which are zoologically arranged. On the other hand, the practical uses of the Geological Survey and Museum would have been seriously imperilled by a transfer to South Kensington. We hope, now that the matter is settled, that proper accommodation will speedily be afforded for the Geological Survey Offices.